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Trend Analysis and Forecasting of Prices of Coconut in Goa State

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Abstract

The research study has been conducted by using secondary data on time series analysis based on monthly prices of Coconut crop from January 2010 to December 2023. The data obtained from the Ministry of Agriculture and Farmer Welfare, Government of India, the Goa Agricultural Produce Livestock Marketing Board (GAPLMB), Goa, and its sub yards. Basic statistical methods such as growth rates, basic averages, and percentages were utilized to examine the data in order to reach relevant conclusions and meet specified objectives. The finding reveals that, coconut prices have significantly increased over time. To forecast the prices of coconut ARIMA model was used. ARIMA model (10,1,12) was the best fitted model for the research investigation. It was observed that predicted prices of coconut were varying with small magnitude. The percentage difference between the predicted price and actual price was small. Hence, ARIMA model was the most representative model for the prices of coconut in the study market.

Key words: Time series, coconut, prices, GAPLMB, ARIMA, forecasting

Introduction

Regulated market is the market which is regulated by State Government through the market committee, which works to protect consumer and producer interests by dealing with fraudulent and unhealthy marketing techniques.

Market news and intelligence about changes in pricing over time help farmers make judgments about the future pattern of sales of agricultural commodities. The main objectives of a regulated market are to encourage fair trade, give farmers access to infrastructure, and facilitate efficient marketing operations by lowering exploitation. The similar goals of regulating, stabilizing prices, and to promote the selling of agricultural products and protect the financial interests of the producer and seller in Goa, the Goa government in 1968 expanded the Maharashtra Agriculture Produce Marketing (Regulation) Act 1963 in their state. The Goa Agricultural Produce Marketing committee was established in 1969, the Goa Agricultural Produce Marketing rules were formulated, and the Act became operative on September 16, 1968. As per the Central Government Model Act, it is the highest authority in the State. Currently, the market region has 27 agricultural commodities that have been notified for regulation

Goa's lateritic soil and warm, humid environment, combined with its tropical location, make it an ideal place for plantation crops. The state's total sown area is 1,44,381 ha, of which 87,630 ha are used for plantation crops. Approximately 26,630 hectares have been covered with coconut plantations (Anonymous, 2021), and some of the plantation crops, such bananas and areca nuts, are intercropped with the coconut trees to improve resource efficiency and provide extra revenue for the growers. Over the base year 2011–12, Goa's coconut area, productivity, and production increased by 3.5 percent, 27.4 percent, and 23.3 percent, respectively.

Methodology

Sampling design

The purposeful selection of the Goa Agricultural Production and Livestock Marketing Board (GAPLMB) Arlem, Goa served as the basis for the study of trend analysis of coconut prices. The information about coconut prices, sorted down by month, was gathered from GAPLMB, Goa databases and Ministry of Agriculture and Farmer Welfare, Government of India (Anonymous, 2024). Data covering the last 14 years, from 2010 to 2023, was gathered based on the information that was obtained.

Analytical techniques:

Trends in Prices

The time series data pertaining to monthly prices of coconut was used and compound growth rates of prices of coconut was worked out by using an exponential form of equation as below

$$\mathbf{Y = ab^t}$$

Where,

Y = Monthly prices

a = Constant
b = Trend coefficient
t = Time period

Annual compound growth rate (CGR) in percentage was calculated as,

CGR (%) = (Antilog of b-1) × 100

Seasonal indices of prices of coconut

Seasonal indices are those periodic movements in business activity which occur regularly every year and have their origin in the year itself. Specific seasonal index refers to the seasonal changes during a particular year. Seasonal indices were given as percentage of their averages.

The seasonal indices of prices of coconut were calculated using simple average method.

$$\textbf{SI} = \frac{\textbf{Monthly arrival /prices}}{\textbf{Average of arrival /prices}} \textbf{ X } \textbf{100}$$

Forecasting the Future Prices of Coconut

For quantifying and forecasting the future prices for a given set of data **Auto Regressive Integrated Moving Average (ARIMA) Model (Box-Jenkins models)** model was used. The outline of the model is as below.

The main objective in fitting ARIMA model is to identify the stochastic process of the time series and predict the future values accurately. These methods have been also useful in many types of situation which involve the building of models for discrete time series and dynamic systems. But, this method is not good for lead times or for seasonal series with a large random component. Originally ARIMA models had been studied extensively by Box and Jenkins and their names have frequently been used synonymously with general ARIMA process applied to time series analysis, forecasting and control. The main stages in setting up a Box-Jenkins forecasting model are as follows.

1. Identification
2. Estimating the parameters
3. Diagnostic checking and
4. Forecasting

(1) Identification of Models

A good starting point for time series analysis is a graphical plot of the data. It helps to identify the presence of trends.

Before estimating the parameter p and q of the model, the data are not examined to decide about the model which best explains the data. This is done by examining the sample ACF (Autocorrelation function) and PACF (Partial Autocorrelation function) of differenced series Y_t.

The sample auto correlations for k time lags can be found and denoted by r_k as follows.

$^{\wedge}Pk\ (Y_t) = r_k\ (Y_t)$ ……… (10)

$= C_k\ (Y_t) / C_0\ (Y_t)$

$C_k\ (Y_t) = 1/n\ S\ (Y_t - Y)\ (Y_{t+k} - Y)$

k = 0, 1, 2, ...n

t = 1, 2, . . . n-k

$Y_t = 1/n \sum Y_t$

n = Length of time period

Both ACF and PACF are used as the aid in the identification of appropriate models. There are several ways of determining the order type of process, but still there was no exact procedure for identifying the model.

(2) Estimation of Parameters

After tentatively identifying the suitable model, next step is to obtain Least Square Estimates of the parameters such that the error sum of squares is minimum.

$S(\theta, \emptyset) = S\, e_t^2 (\theta,\emptyset)$ ……… (11)

Where,

t = 1, 2, 3, . . . n

There are fundamentally two ways of getting estimates for such parameters.

Trial and Error: Examine many different values and choose set of values that minimizes the sum of squares of residuals.

Interactive Method: Choose a preliminary estimate and let a computer programmed refine the estimate interactively.

The latter method is used in our analysis for estimating the parameters.

(3) Diagnostic Checking

After having estimated the parameters of a tentatively identified ARIMA model, it is necessary to do diagnostic checking to verify that the model is adequate.

Examining ACF and PACF of residuals may show an adequacy or inadequacy of the model. If it shows random residuals, then it indicates that the tentatively identified model is adequate. When an inadequacy is detected, the checks should give an indication of how the model need be modified, after which further fitting and checking takes place.

One of the procedures for diagnostic checking mentioned by Box-Jenkins is called over fitting i.e. using more parameters than necessary. But the main difficulty in the correct identification is not getting enough clues from the ACF because of inappropriate level of differencing. The residuals of ACF and PACF considered random when all their ACF were within the limits.

$\pm 1.96\sqrt{1/(n-12)}$ ……… (12)

We also used Box and Pierce 'Q' statistic for whether the auto correlations for these residuals are significantly different from zero. It can be computed as follows.

$Q = n \sum_{K}^{m} rk^2$ ……… (13)

Where,

m = Maximum lag considered

n = N – D

N = Total number of observations

rk = ACF for lag k

D = Differencing

And Q is distributed approximately as a Chi-square statistic with (m-p-q) degree of freedom.

The minimum Akike Information Coefficient (AIC) criteria is used to determine both the differencing order (d, D) required to attain stationarity and the appropriate number of AR and MA parameters, it can be computed as follows.

$$\textbf{AIC (p+q)} = N \ln\sigma^2 + 2(p+q) \qquad \text{……… (14)}$$

Where,

σ^2 = Estimated MSE

N = Number of observations

(p+q) = Number of parameters to be estimated.

This diagnostic checking helps us to identify the differences in the model, so that the model could be subjected to modification, if need be.

(4) Forecasting

After satisfying about the adequacy of the fitted model, it can be used for forecasting. Forecasts based on the model.

$$(1-ØB)(1-\varphi B)sY_t = (1-\theta B)(1-(H)sB)\,e_t \qquad \text{……… (15)}$$

This was computed for upto 36 months (m) ahead. The above model (15) gives the forecasting equation is

$$Y_t = ØY_t\text{-}1 + \varphi Y_{t-12} - Ø\varphi Y_{t-13} + e_t - \theta e_{t-1} - (H)\,e_{t-12} + \theta(H)\,e_{t-13} \text{…… (16)}$$

Given data upto time 't' the optional forecast of Y (also called Ex-Ante forecast) model at the t is the conditional expectation of Y_{t+1}.

It follows, in particular, that

$$e_t = Y_t - Y_{t-1} \qquad \text{……… (17)}$$

The errors et in model (17) are in fact that forecast errors for unit lead time. That for an optimal forecast these 'one step ahead' forecast errors ought to form an uncorrelated series is otherwise obvious. Suppose, if these forecast errors were auto correlated, then it could be possible to forecast the next forecast error in which case it could not be optimal.

The required expectations are easily found because

$$E(Y_{t+m}) = Y_t(m),\ E(e_{t+m}) = 0 \qquad \text{……… (18)}$$

Where,

m = 1, 2, 3 ……….n

$$E(Y_{t-m}) = Y_{t-m}\ E(e_{t-m}) = a_{t-m} = Y_{t-m} - Y_{t-m-1} \qquad \text{……… (19)}$$

Where, m = 0, 1, 2, ...n

For instance, to determine the three month ahead (1-3) forecast for series Y_t
(use equation 16).

$Y_{t+1} = Y_{t+3}$

$= ØY_{t+2} + \varphi Y_{t-9} - Ø\varphi Y_{t-10} + e_{t+13} - \theta e_{t-2} - (H)\,e_{t-9} + \theta(H)\,e_{t-10}$

taking conditional expectations at time t,

$Y_t(1) = Y_t(3)$

$= ØY_t(2) + \varphi y_{t-9} - Ø\varphi Y_{t-10} + 0 - \theta(0) - (H)(Y_{t-9} - Y_{t-10}) + \theta(H)(Y_{t-10} - Y_{t-11})$

Because, $E(e_{t+1}) = 0$, $E(e_{t-1}) = Y_{t-1} - \hat{Y}_{t-1} = e_{t-1}$

i.e. $Y_t(3) = 0\ Y_t(2)$.

The forecast $Y_t(2)$ can obtained in a similar way in terms of $Y_t(1)$ from $E(Y_{t+2})$. Similarly$Y_t(1)$ can be obtained from $E(Y_{t+1})$. In practice it is very easy to compute the forecast $Y_t(1)$, $Y_t(2)$, $Y_t(3)$ *etc.* recursively using the forecast function (18).

E (Y_{t+1}) = E (0Y_{t+1}-1 + Q_{t+1}-0 e_{t+1}-1) - θe_{t+1}-1 - (H) e_{t+1}-12 + θ (H) e_{t+1}-13 and using 18 and 19 (Box, G.E.P, 1970).

However, using these methods, Ex-post forecasts can also be calculated for comparing with the value actually realized.

Analysis and discussion

Monthly Average Prices of Coconut in GAPLMB, Goa

The data of fourteen years (2010-2023) of the coconut prices was collected and analysed for the present study. The annual monthly prices of coconut is presented in Table 1. It can be observed from the table that the average prices of coconut were almost steady for the months during study period. Highest price was observed in the month of February (₹8500/'000'nuts) and lowest was in the month of July (7142.86). So as we can see, we can suggest the Goan farmers to sell the coconut in yards in the month from January to April to get the more profit. The highest average price of mustard was observed in the month of October-November when the arrivals were supposed to be the lowest. (Sarkar *et al.* 2021).

Table. 1. Monthly Average Prices of Coconut in GAPLMB, Goa

Sr. No.	**Months**	**Coconut**
		Prices (₹/000 nuts)
1	January	8303.57
2	February	8500.00
3	March	8435.71
4	April	8232.14
5	May	8021.43
6	June	7678.57
7	July	7142.86
8	August	7789.29
9	September	7855.71
10	October	7942.86
11	November	7839.29
12	December	7953.57

Compound Annual Growth Rate of Prices of Coconut in GAPLMB, Goa

For the period of 2010–2023, the compound annual growth rate (CAGR) of prices of coconut was evaluated by fitting an exponential type of equation, and the results are depicted in Table 1.2.

It is seen from table that, the coconut prices showed significant increase over the years at the rate of 8.42% annually. Study showed that there is a positive and significant growth rate of prices of selected commodities. There was a significant increase in the prices of all the commodities throughout the study period. (Dhende *et al.* 2020). The highest in case of coriander (7.55%) followed by soybean (7.24%) and lowest in jeera with (5.69%), respectively. (Kachroo and Nazir, 2021)

The prices of potato significantly increased over the last ten years compounded annually in all the selected markets.(Sreepriya and Sidhu, 2020).

Table 2. Compound Annual Growth Rates of Prices of Coconut (2010-2023)

(Per cent)

Sr.No.	Crops	Prices
1	Coconut	**8.42*** **

(*, ** and *** indicates significance at 5, 10 and 1 per cent, respectively)

Seasonal Indices of Prices of Coconut

Data seasonality is measured by use of seasonal indices. It is the periodic movement in business activity which occurs regularly every year. It's the regular, yearly movement in economic activity that happens on a periodic basis. Such fluctuations can be reasonably precisely predicted because they reoccur over a twelve-month period. Table 3 shows the seasonal price indices for coconuts.

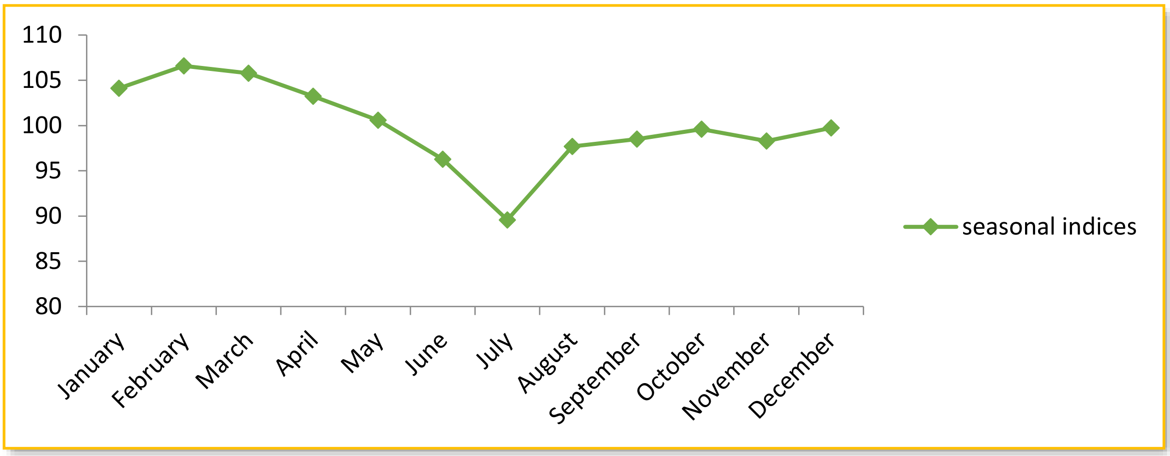
According to the table, price indices fluctuated on a very small scale. February had the highest index for coconut prices (105.81%) and July (89.80%) had the lowest. High seasonal indices indicate higher fluctuations in magnitudes of prices in the market.

Table.3 **Seasonal Indices of Prices of Coconut**

Sr. No	**Seasonal Indices of Coconut**	
	Month	Seasonal Indices
1	January	104.13
2	February	106.59
3	March	105.78
4	April	103.23
5	May	100.59
6	June	96.29
7	July	89.57
8	August	97.68
9	September	98.51
10	October	99.60
11	November	98.30
12	December	99.74

The seasonal index for prices of apple being lowest in the month of April (0.19%) and the highest in August (160.66%) (Ali *et al.* 2018). In the case of fenugreek and fennel, the highest seasonal indices of arrivals and price were observed in May (240.18) December (110.95), April (590.71) and August (122.03), respectively (Bairwa *et al.* 2021).

Fig.1. Seasonal Indices Prices of coconut



Forecasting of Coconut Prices in Goa State

Prices of agricultural produce fluctuate seasonally as a result of changes in production, market arrivals, and storage. Therefore, it is very important from a practical standpoint to predict the monthly price behavior over time to safeguard the interest of farmers. Estimating the future values based on historical and present data is known as forecasting. The Auto Regressive Integrated Moving Average (ARIMA) model, developed by Box and Jenkins in 1970, has been widely used to identify patterns in time series data and predict future values. The forecasting models are sometimes expressed in abbreviated form as ARIMA (p, d, q), where "p" denotes the "AR" portion, "d" denotes the "I" portion, and "q" denotes the "MA" portion. This study employed the ARIMA model, which had four stages and need for a sizable data collection. Four stages consist of identification, model estimation, diagnostic testing and forecasting. In order to fit the ARIMA models, model parameters were computed using the statistical packages for social sciences (SPSS) software

Stages of Forecasting

The following section has detailed analysis of price forecasting stages for coconut crop in Goa state.

a. Identification of the Model

The computation of auto-correlation (ACF) and partial auto-correlation functions (PACF), which are shown in the fig. 2. for coconut was used to achieve stationary series. After converting the variables into stationary series through analysis of non-seasonal or seasonal or both, order of differencing, ARIMA model was estimated. The presence of seasonality in the data was discovered after a detailed analysis of ACF and PACF. The significance of each individual coefficient of the ACF and PACF was examined using the t test. Additionally, the absence of a peak at the first values demonstrated that the non-seasonal difference of d=1 was a suitable choice for achieving stationary series. Therefore, a variety of models were investigated based on ACF and PACF. Finally, it was determined that models (10,1,12) was the best models for predicting the prices of coconut in Goa state.

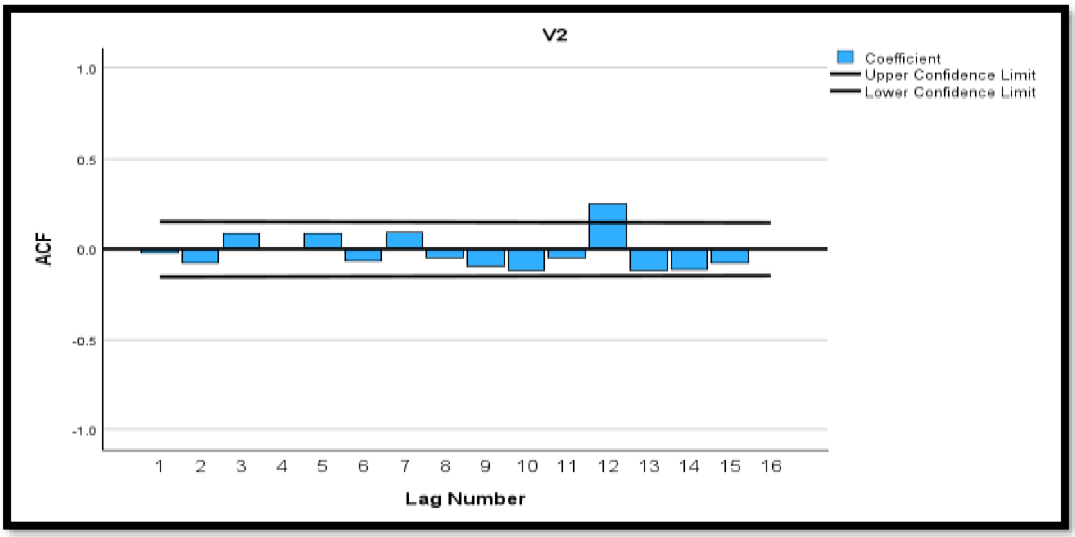
b. Model estimation

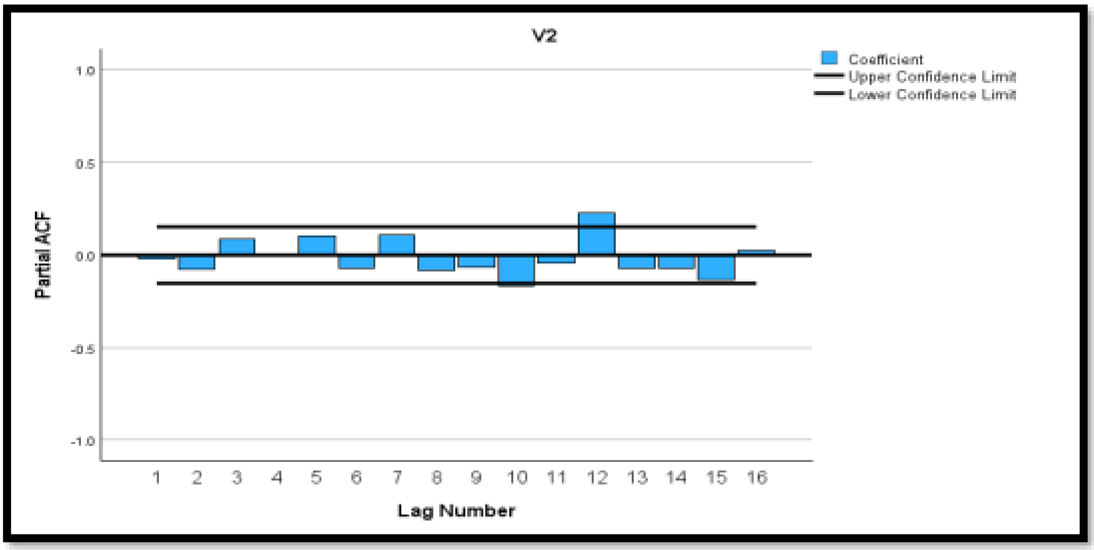
The model parameter was analyzed using the SPSS software, and the result depicted in Table 4. It was noted from this Table 4 that the R^2 was 0.942. The ARIMA (10,1,12) model had the lowest value of the normalized BIC, which is 14.16 and showed that it was the best model for forecasting coconut prices.

Table 3. Estimates of the ARIMA Model Fitted for Coconut Prices

Sr. No.	Parameter	Estimates	SE ±	t value	Sig.
1	Constant	36.628	33.092	1.107	.270
3	Df	00			
	R^2	94			
5	BIC Value	14.116			

Fig. 3. ACF and PACF of Coconut Prices





c. Diagnostic Checking

Table 3 showed the results of statistics. Since the BIC statistic was found to be non-significant, the model (10,1,12) was determined to be the best model for prices for coconut. Yt = 2802.98 - 0.621$_{Yt-1}$-0011 $_{et-1}$. was the fitted ARIMA model for the coconut price data.

d. Forecasting of Prices

Post-forecasting was completed, and the results were compared to the actual values of the observations. Till May 2026, forecasting was made of prices of coconut. The forecasting of the market price for coconuts are displayed in the Table 4 and also depicted in Fig. 2

It could be seen from Table 4 and fig. 3 there were narrow variations has been observed between the actual and forecasted values of prices of coconut in the GAPLMB, Goa. As per forecasted result, the prices will be high in the month of September 2024 i.e ₹ 13208/1000 nuts and low during the month of February 2026 i.e. ₹ **8577**/1000 nuts. It was clear from the Table 4 that the difference between actual and predicted price ranges between 5-15 per cent with some exceptions. This indicates that the ARIMA model was the most reprentative model for price forecasting of coconut. The ARIMA (2, 1, 2) model was the best model for the price forecast of chilli.(Kumari *et al.* 2019). Based on the above criteria, the model (1,1,1) was found to fit the time series to predict future prices (Areef *et. al*. 2020).

Fig. 2 Ex-ante and Ex-post Forecast of Monthly Prices of Coconut

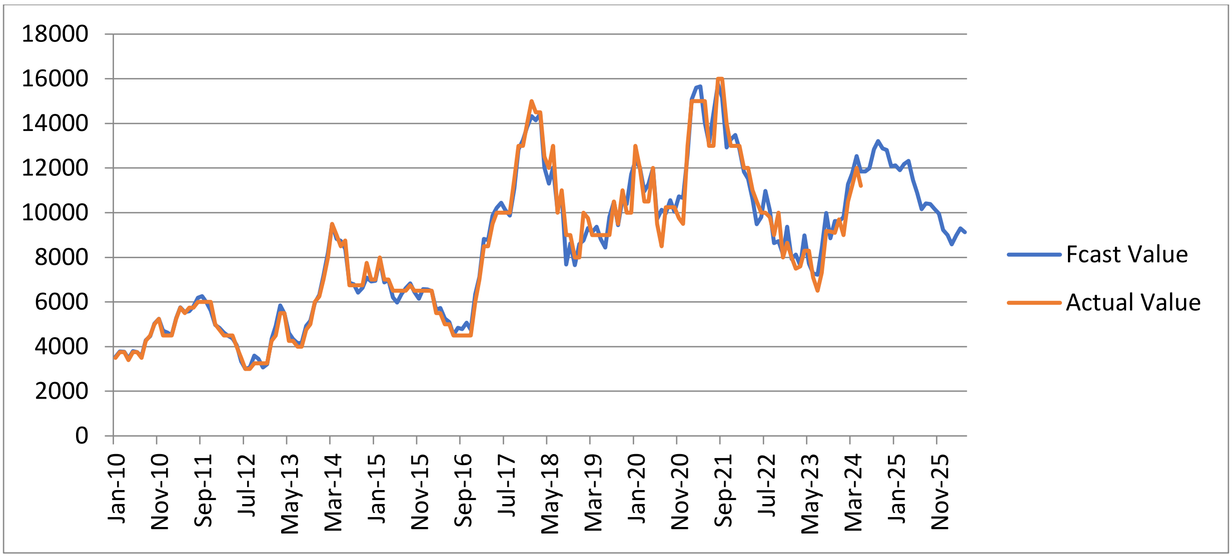


Table 4. **Ex-ante and Ex-post Forecast of Monthly Prices of Coconut**

Month	Prices (₹/1000 nuts)			Month	Prices (₹/1000 nuts)		
	Actual	**Predicted**	**Differene (%)**		**Actual**	**Predicted**	**Difference (%)**
Jan-20	**12326**	13000	-5.18	Jun-23	**7271**	7100	2.41
Feb-20	**12030**	12000	0.25	Jul-23	**7217**	6500	11.03
Mar-20	**10960**	10500	4.38	Aug-23	**8391**	7300	14.95
Apr-20	**11282**	10500	7.45	Sep-23	**9979**	9180	8.70
May-20	**11990**	12000	-0.08	Oct-23	**8854**	9160	-3.34
Jun-20	**9714**	9500	2.25	Nov-23	**9628**	9100	5.80
Jul-20	**10130**	8500	19.18	Dec-23	**9612**	9700	-0.91
Aug-20	**9970**	10250	-2.73	Jan-24	**9797**	9000	8.86
Sep-20	**10562**	10250	3.04	Feb-24	**11269**	10500	7.32
Oct-20	**10036**	10250	-2.09	Mar-24	**11756**	11200	4.96
Nov-20	**10737**	9750	10.12	Apr-24	**12532**	12000	4.43
Dec-20	**10665**	9500	12.26	May-24	**11854**	11200	5.84
Jan-21	**12589**	13000	-3.16	Jun-24	**11852**	-	
Feb-21	**15078**	15000	0.52	Jul-24	**11990**	-	-
Mar-21	**15606**	15000	4.04	Aug-24	**12837**	-	-
Apr-21	**15665**	15000	4.43	Sep-24	**13208**	-	-
May-21	**14029**	15000	-6.47	Oct-24	**12884**	-	-

Jun-21	**13120**	13000	0.92	Nov-24	**12802**	-	-
Jul-21	**14453**	13000	11.18	Dec-24	**12082**	-	-
Aug-21	**15761**	16000	-1.49	Jan-25	**12122**	-	-
Sep-21	**15158**	16000	-5.26	Feb-25	**11909**	-	-
Oct-21	**12915**	14000	-7.75	Mar-25	**12173**	-	-
Nov-21	**13286**	13000	2.20	Apr-25	**12314**	-	-
Dec-21	**13479**	13000	3.68	May-25	**11465**	-	-
Jan-22	**12852**	13000	-1.14	Jun-25	**10889**	-	-
Feb-22	**11828**	12000	-1.43	Jul-25	**10163**	-	-
Mar-22	**11519**	12000	-4.01	Aug-25	**10420**	-	-
Apr-22	**10608**	11000	-3.56	Sep-25	**10389**	-	-
May-22	**9490**	10500	-9.62	Oct-25	**10170**	-	-
Jun-22	**9796**	10000	-2.04	Nov-25	**9959**	-	-
Jul-22	**10972**	10000	9.72	Dec-25	**9223**	-	-
Aug-22	**10106**	9800	3.12	Jan-26	**9000**	-	-
Sep-22	**8638**	9000	-4.02	Feb-26	**8577**	-	-
Oct-22	**8732**	10000	-12.68	Mar-26	**8979**	-	-
Nov-22	**8135**	8000	1.69	Apr-26	**9305**	-	-
Dec-22	**9366**	8650	8.28	May-26	**9130**	-	-
Jan-23	**7925**	8000	-0.94				
Feb-23	**8121**	7500	8.28				
Mar-23	**7634**	7600	0.45				
Apr-23	**8980**	8300	8.19				
May-23	**7715**	8300	-7.05				

Conclusions

The annual compound growth rate showed significant increase in prices of coconut crop in Goa state. The annual growth rate was 8.42 with 1 per cent level of significance. Seasonal indices for prices was more in January to April as compare to other month indicating the more price during this period, hence growers could be advice to sell their produce during the aforesaid months. Forecasting the prices of coconut showed a narrow variation between the actual prices and forecasted prices. This indicates that the ARIMA model could be used successfully for modeling as well as for predicting monthly prices of coconut.

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