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Forecasting area, productivity and prices of mango in Valsad District of Gujarat: Time series analysis

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ABSTRACT

Mango on an average account approximately 75 per cent of total production quantity. India is the largest mango producer, accounting for about half of the world-wide mango production. Forecasting of area, production and price fluctuations are the key to provide support in decision making and proper planning for sustainable growth of farmers and other people who are dependent on horticulture. The prices of mango are affected by cultivated area and yield of mango but in other ways pre or post-harvest management also affects it. The problems regarding the price fluctuations arise due to seasonality in arrival and its perishable nature. Therefore, the present study was carried out with time series intervention modelling in forecasting area, productivity and prices of mangoes. In the current investigation, simple exponential smoothing (SES) implemented to develop the forecasting models for area and productivity of mango. Under the SES, the error measurements at different values of alpha (α) for forecasting of area and productivity were observed that the value 0.8 and 0.9 of alpha (α) showed minimum Mean Absolute Percentage Error (MAPE) error i.e. 3.11 per cent, and 12.73 per cent, respectively. The study also developed time series ARIMA models for forecasting the prices of the mango (Keshar and Alphonso) for Valsad markets of Gujarat. It was showed that ARIMA (6, 1, 2) and ARIMA (1, 1, 2) were found good models for forecasting the prices of the Keshar and Alphonso, respectively in Valsad district of Gujarat.

Introduction

Mango is referred to as the "*King of fruits*" because of its overall rich eating characteristics. India is the main producer and consumer of mangoes and it ranks first among world's mango producing countries accounting for about 50 per cent of the world's mango production. Fruits and vegetables account for nearly 90 per cent of the total horticulture production in the country which plays an important role in horticulture, agriculture and Indian economy. It is consumed as a fresh fruit, preserved, in the frozen, dried forms, processed into juices, purees, chutneys and pickles etc. In the horticulture industry, fruit productivity and area consecration under mango stand at the top position and it covers 21.83 per cent of total fruits crops area and holds the second rank in total fruits production 35.53 per cent (Singh *et al.* 2018). The Gujarat is fifth largest mango producing state in India and Valsad is first

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largest mango producing district in Gujarat with a production of 237,203 million tons with 36,890 ha area. (Anonymous, 2021). In India, it has good scope for increasing the area and productivity of mango due to demand for mango fruit is growing per annum. The procedure, time and place efficacies adjust production, consumption and which help making efficient marketing decisions. Time series forecasts are statistical methods designed to identify patterns in series data that can be predicted in the future. But it also concluded that very often, the future will not look like the past, and we need insight into how, and why, the future will look different and that is the role of market intelligence (Moon, 2013). Considering the facts, present study swotted the several researches on forecasting. Yusuf and Sheu (2007), studied trend analysis for forecasting of future production of citrus and mango in Nigeria using various forecasting techniques up to the year 2010. Khan *et al.* (2008) predicted the production of Mango in Pakistan using a log linear model and ARIMA modelling approach. Pradhan (2012) utilised ARIMA model for forecasting agricultural productivity in India. Qureshi *et al.* (2014), Hamjah (2014) and Pardhi *et al.* (2017) developed Box-Jenkins ARIMA model to forecast production of Mango. Rathod and Mishra (2017) developed weather based models by using methods of stepwise regression analysis and ARIMA model to forecast area and production of mango. Kumar and Gupta (2020) have obtained forecast values for the production and area of Mango by using Autoregressive, Exponential and Gompertz models.

Material and Methods

The study area Valsad is located at Latitude 20.63^{0}N, Longitude 72.93^{0}E having an average elevation of 13 meter above sea level. Major horticultural crops that are produced in the Valsad district are mango, sapota, papaya, guava, cucurbits and banana. Valsad is famous for Alphonso (*Valsadi Haafus*) and *Keshar*. Therefore it is also called a horticulture hub of Gujarat and Mango capital of Gujarat. The study utilised the time series secondary data on area and productivity of the mango starting from the year 2002-03 to 2019-20 which was collected from Directorate of Horticulture, Gandhinagar, Gujarat. The price data of mango for different markets under Valsad was collected from website of Directorate of Marketing & Inspection (DMI), Ministry of Agriculture and Farmers Welfare, Government of India (https://agmarknet.gov.in/). The major markets of Valsad district viz. Valsad, Pardi, Dugari and Chikli were selected purposively based on availability of the data. The price forecasting was carried out for major growing varieties of mango i.e. Keshar and Alphonso. The weekly average of all market prices under the Valsad districts were utilized for forecasting. The weekly missing price data were interpolated.

Statistical techniques

The analytical tool adopted are Simple Exponential smoothing (SES) and Box-Jenkins Autoregressive models (ARIMA) techniques are discussed below. The software EViews 9.1 was used for time series data analysis.

Simple Exponential smoothing (SES)

The simple exponential smoothing (SES) technique is based on averaging series data of a series in a decreasing (exponential) manner. This particular method is generally utilized when forecasting data has no clear trend or seasonal pattern. Exponential Smoothing assigns exponentially increasing or decreasing weights (smoothing constant) to the data series over time. The smoothing constant value is higher for most recent value and lesser for the older data points. The value of smoothing constant i.e. alpha is always taken between 0 & 1 because if the value of smoothing constant is greater than 1, then the expression of single exponential smoothing acquires negative value which denotes the failure of the method. The forecast of area and productivity, for the period *t+1* is given by Box *et al.* (1994).

$$F_{t+1} = F_t + \alpha\,(Y_t - F_t)$$

$$F_{t+1} = \alpha\, Y_t + (1 - \alpha)\, F_t$$

(*on simplification*)

Where, F_{t+1} = Forecast value for period $t+1$
F_t = Forecast value for period t
α = Smoothing constant
Y_t = Actual value for period t (Area and productivity)

The value of α lies between 0 and 1. The large value of α (say 0.9) gives very little smoothing in the forecast, whereas a small value of α (say 0.1) gives acceptable smoothing. Alternatively, it can be chosen (α) from a set of values (say α = 0.1, 0.2, 0.3,…, 0.9) and finally choose the value that yields the minimum MSE value (Kumari *et al.*, 2017, Garde *et al*, 2022).

Box-Jenkins Autoregressive models (ARIMA)

The stationarity of the data was carried out with Augmented Dickey-Fuller (ADF) Test (Unit root test) before initializing the operational steps of ARIMA. The model is usually stated as ARIMA (*p, d, q*), where, *p* denotes orders of auto-regression, *d* means integration (differencing) and *q* represents moving average. The Box and Jenkins proposed a practical four-stage procedure for finding a good model. A) Identification b) Estimation of parameters c) Diagnostic checking and d) Forecasting (Garde *et al*, 2022). The forecasting through ARIMA model was carried by using E-Views 9.0 statistical software, viz., checking the stationarity through Augmented Dickey-Fuller (ADF) test, identification of tentative models based on scrutiny of the parameters of the selected models were estimated by maximum likelihood Estimation (MLE) method. The adequacy of the model was judged based on the significance of Ljung-Box 'Q' Statistic using residual diagnostics (Box and Jenkins 1994, Brockwell and Davis 1996).

The performance of developed models

The identification of the suitable forecasting models for area, productivity and prices of mango were done using different goodness of fit techniques viz. Adj.R^2, Forecast error (%), Mean Absolute Percentage Error (MAPE), Root mean square error (RMSE), and Thiel's inequality coefficient (U). The forecasting performance of the developed model is excellent, when $U = 0$. Also when $U = 1$ that means the predicting performance is not improved by just using the last observed value as a forecast. (Friedhelm, 1973).

Results and Discussion

Forecasting of the area and productivity of mango using exponential models

In the present study, the simple exponential smoothing (SES) was adopted to forecast the value of area (ha) and productivity (mt ha^{-1}) for the Valsad district. The below Table 1, showed the error measurements at different values of alpha (α) for forecasting of area (ha) and productivity (mt ha^{-1}) in the Valsad district. Here values of α were selected from a grid of values viz. 0.2, 0.4, 0.6, 0.8, 0.9. Depending upon these values, the forecast with minimum error measurement and corresponding smoothing constant were selected. It was observed from Table 1 that for the value of alpha (α) 0.8 and 0.9 showed minimum MAPE error i.e. 2.56 per cent and 12.73 per cent which was low among all other values of alpha for area and productivity, respectively. Also for other values of alpha, Root Mean Error Percentage (RMSE) was high. The graphical representation of actual and forecast values of area and productivity of mango in Valsad district is given in Figure 1.

Forecasting of the prices (Rs./q) of mango using ARIMA models

The detailed analysis of forecasting of mango prices (Rs./q) for the variety of Keshar and Alphonso in Valsad district are discussed separately under following sub-heads.

KESHAR

Stationarity check

Table 2 revealed that Augmented Dickey-Fuller (ADF) unit root test statistic at level (no difference) was accepted the null hypothesis i.e. prices data of Keshar mango has a unit root (non-stationary). The probability value were more than rejection values at 1 per cent level of the significance (*p*-0.0181) thus analysis was proceeding further by taking 1st differencing and again tested stationarity. Table 2 showed that at 1st differencing the null hypothesis for test statistic was rejected which indicated prices data of Keshar mango had stationarity (*p*-0.0000). Therefore ARIMA model identification was proceed with taking value, d= 1.

Identification of the model

The tentative models were first identified based on the Auto-Correlation Function (ACF) and Partial Auto-Correlation Function (PACF) plots shown in Figure 2. Based on numbers of spike outside the confidence level in the correlogram, the all possible combination of the *p* and *q* values were carried out for identification of the best model. The method of ARMA maximum likelihood was applied for model development. The tentatively identified five models for forecasting prices of Keshar mango and are presented in Table 3. It has also indicated the values of Akaike Information Criteria (AIC) and Schwarz Bayesian Information Criteria (SIC) along with adjusted R^2 and SIGMASQ. Based on the lower the value of AIC, SIC and SIGMASQ with higher value of Adjusted R^2 the selected model was

Table 1: Forecast validation using different values of weight (α) using SES method

Valsad	α	Damping factor (1-α)	MSE	RMSE	MAPE (%)
Area	0.9	0.1	1885340.51	1373.08	3.26
	0.8	**0.2**	1447874.41	1203.28	**3.11**
	0.6	0.4	1508140.42	1228.06	3.37
	0.4	0.6	3853917.55	1963.14	5.45
	0.2	0.8	24176012.96	4916.91	13.74
Productivity	**0.9**	**0.1**	2.09	1.44	**12.73**
	0.8	0.2	2.14	1.46	13.67
	0.6	0.4	2.30	1.51	16.91
	0.4	0.6	2.39	1.54	19.77
	0.2	0.8	2.16	1.47	19.90

Table 2: Stationarity (ADF) test

ADF test at level

Null Hypothesis: KESHAR_PRICE has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on AIC, maxlag=12)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-3.281056	0.0181
Test critical values:	1% level		-3.489117	
	5% level		-2.887190	
	10% level		-2.580525	

ADF test at 1st differencing

Null Hypothesis: D(KESHAR_PRICE) has a unit root				
Exogenous: Constant				
Lag Length: 1 (Automatic - based on AIC, maxlag=12)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-8.650301	0.0000
Test critical values:	1% level		-3.490210	
	5% level		-2.887665	
	10% level		-2.580778	

Table 3: Identification of ARIMA model

ARIMA Model →	(6, 1, 2)	(2, 1, 6)	(2, 1, 2)	(0, 1, 2)	(2, 1, 0)
AIC	15.380	15.401	15.413	15.409	15.425
SIC	15.482	15.503	15.516	15.486	15.501

Table 4: Estimation of coefficients of the ARIMA model through residual diagnostics

Dependent Variable: D(KESHAR_PRICE)				
Method: ARMA Maximum Likelihood (OPG - BHHH)				
Sample: 3 105				
Included observations: 103				
Convergence achieved after 17 iterations				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	24.01931	24.27641	0.989410	0.3249
AR(6)	-0.261532	0.172739	-1.514032	0.1333
AR(3)	-0.143158	0.129989	-1.101314	0.2735
MA(2)	-0.328782	0.142659	-2.304675	0.0233
MA(13)	-0.176468	0.140555	-1.255512	0.2123
SIGMASQ	241607.0	23897.69	10.11006	0.0000
R-squared	0.179801	Mean dependent var		30.67867
Adjusted R-squared	0.137523	S.D. dependent var		545.3983
S.E. of regression	506.5094	**Akaike info criterion**		15.36126
Sum squared resid	24885522	**Schwarz criterion**		15.51474
Log likelihood	-785.1051	Hannan-Quinn criter.		15.42343
F-statistic	4.252806	Durbin-Watson stat		2.037531
Prob(F-statistic)	0.001539			

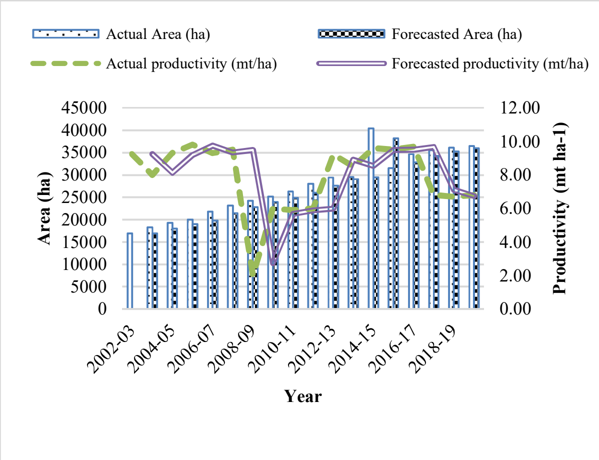
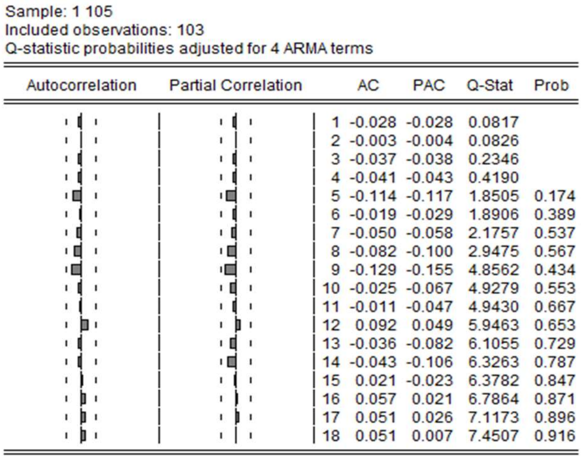


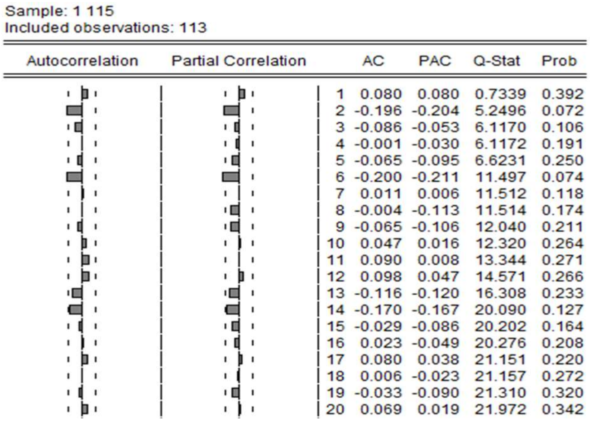
Figure 1: Graphical representation of actual and forecast values of area and productivity of mango



Sample: 1 105
Included observations: 103
Q-statistic probabilities adjusted for 4 ARMA terms

	AC	PAC	Q-Stat	Prob
1	-0.028	-0.028	0.0817	
2	-0.003	-0.004	0.0826	
3	-0.037	-0.038	0.2346	
4	-0.041	-0.043	0.4190	
5	-0.114	-0.117	1.8505	0.174
6	-0.019	-0.029	1.8906	0.389
7	-0.050	-0.058	2.1757	0.537
8	-0.082	-0.100	2.9475	0.567
9	-0.129	-0.155	4.8562	0.434
10	-0.025	-0.067	4.9279	0.553
11	-0.011	-0.047	4.9430	0.667
12	0.092	0.049	5.9463	0.653
13	-0.036	-0.082	6.1055	0.729
14	-0.043	-0.106	6.3263	0.787
15	0.021	-0.023	6.3782	0.847
16	0.057	0.021	6.7864	0.871
17	0.051	0.026	7.1173	0.896
18	0.051	0.007	7.4507	0.916

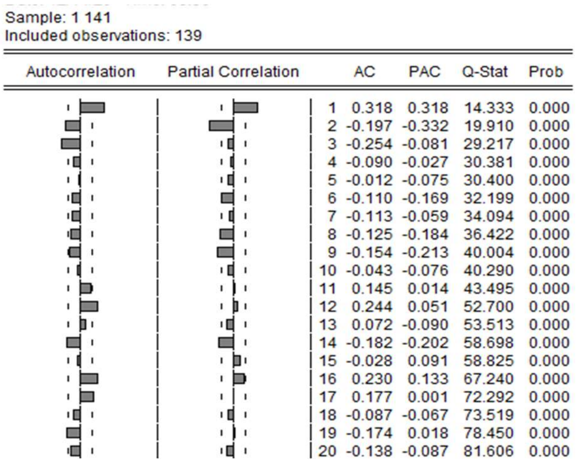
Figure 3(b): Residual diagnostic AR(6), AR(3), MA(2), MA(13)



Sample: 1 115
Included observations: 113

	AC	PAC	Q-Stat	Prob
1	0.080	0.080	0.7339	0.392
2	-0.196	-0.204	5.2496	0.072
3	-0.086	-0.053	6.1170	0.106
4	-0.001	-0.030	6.1172	0.191
5	-0.065	-0.095	6.6231	0.250
6	-0.200	-0.211	11.497	0.074
7	0.011	0.006	11.512	0.118
8	-0.004	-0.113	11.514	0.174
9	-0.065	-0.106	12.040	0.211
10	0.047	0.016	12.320	0.264
11	0.090	0.008	13.344	0.271
12	0.098	0.047	14.571	0.266
13	-0.116	-0.120	16.308	0.233
14	-0.170	-0.167	20.090	0.127
15	-0.029	-0.086	20.202	0.164
16	0.023	-0.049	20.276	0.208
17	0.080	0.038	21.151	0.220
18	0.006	-0.023	21.157	0.272
19	-0.033	-0.090	21.310	0.320
20	0.069	0.019	21.972	0.342

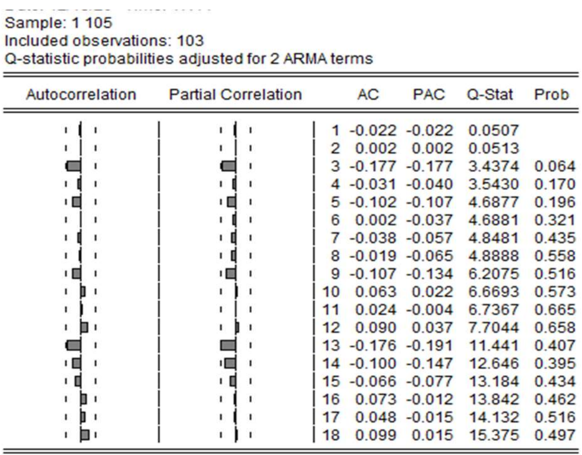
Figure 2: Correlogram at first differencing



Sample: 1 141
Included observations: 139

	AC	PAC	Q-Stat	Prob
1	0.318	0.318	14.333	0.000
2	-0.197	-0.332	19.910	0.000
3	-0.254	-0.081	29.217	0.000
4	-0.090	-0.027	30.381	0.000
5	-0.012	-0.075	30.400	0.000
6	-0.110	-0.169	32.199	0.000
7	-0.113	-0.059	34.094	0.000
8	-0.125	-0.184	36.422	0.000
9	-0.154	-0.213	40.004	0.000
10	-0.043	-0.076	40.290	0.000
11	0.145	0.014	43.495	0.000
12	0.244	0.051	52.700	0.000
13	0.072	-0.090	53.513	0.000
14	-0.182	-0.202	58.698	0.000
15	-0.028	0.091	58.825	0.000
16	0.230	0.133	67.240	0.000
17	0.177	0.001	72.292	0.000
18	-0.087	-0.067	73.519	0.000
19	-0.174	0.018	78.450	0.000
20	-0.138	-0.087	81.606	0.000

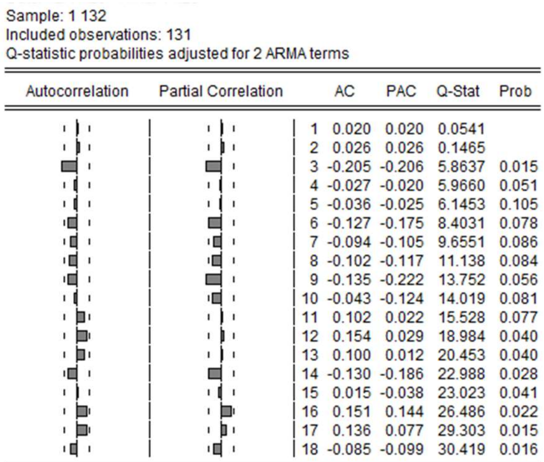
Figure 4: Correlogram at first differencing



Sample: 1 105
Included observations: 103
Q-statistic probabilities adjusted for 2 ARMA terms

	AC	PAC	Q-Stat	Prob
1	-0.022	-0.022	0.0507	
2	0.002	0.002	0.0513	
3	-0.177	-0.177	3.4374	0.064
4	-0.031	-0.040	3.5430	0.170
5	-0.102	-0.107	4.6877	0.196
6	0.002	-0.037	4.6881	0.321
7	-0.038	-0.057	4.8481	0.435
8	-0.019	-0.065	4.8888	0.558
9	-0.107	-0.134	6.2075	0.516
10	0.063	0.022	6.6693	0.573
11	0.024	-0.004	6.7367	0.665
12	0.090	0.037	7.7044	0.658
13	-0.176	-0.191	11.441	0.407
14	-0.100	-0.147	12.646	0.395
15	-0.066	-0.077	13.184	0.434
16	0.073	-0.012	13.842	0.462
17	0.048	-0.015	14.132	0.516
18	0.099	0.015	15.375	0.497

Figure 3(a): Residual diagonostic AR(6), MA(2)



Sample: 1 132
Included observations: 131
Q-statistic probabilities adjusted for 2 ARMA terms

	AC	PAC	Q-Stat	Prob
1	0.020	0.020	0.0541	
2	0.026	0.026	0.1465	
3	-0.205	-0.206	5.8637	0.015
4	-0.027	-0.020	5.9660	0.051
5	-0.036	-0.025	6.1453	0.105
6	-0.127	-0.175	8.4031	0.078
7	-0.094	-0.105	9.6551	0.086
8	-0.102	-0.117	11.138	0.084
9	-0.135	-0.222	13.752	0.056
10	-0.043	-0.124	14.019	0.081
11	0.102	0.022	15.528	0.077
12	0.154	0.029	18.984	0.040
13	0.100	0.012	20.453	0.040
14	-0.130	-0.186	22.988	0.028
15	0.015	-0.038	23.023	0.041
16	0.151	0.144	26.486	0.022
17	0.136	0.077	29.303	0.015
18	-0.085	-0.099	30.419	0.016

Figure 5(a): Residual diagnostics AR(1), MA(2)

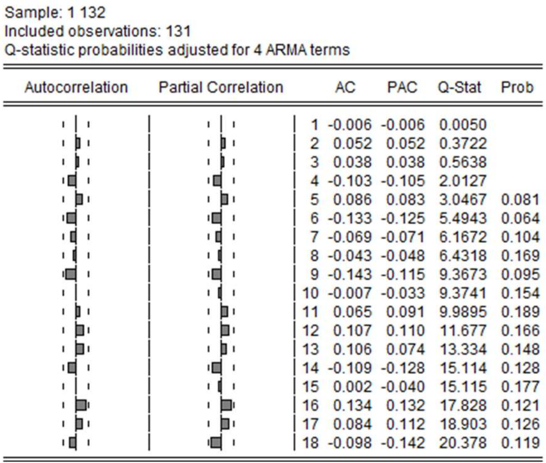


Figure 5(b): Residual diagnostics AR(1), AR(3), MA(2) MA(3)

stated better for forecasting. From Table 3, it was found that ARIMA (6,1,2) was good model for forecasting the prices of the mango (Keshar).

Diagnostic check and estimation of parameters

The residual diagnostics (Correlogram-Q-statistics) was carried out on ARIMA (6,1,2) and estimated the coefficients for good forecast model. Table 4 showed that based on residual diagnostics ARIMA (6,1,2) model was modified by introducing the variables AR(3), MA(13) with existing AR(6) and MA(2). The graphical representation of the residuals of the correlogram are shown in Figure 3 (a) & (b).

Validation of model and Forecasting

The cross validation of the selected model was done based on RMSE, MAPE and Theil inequality coefficient. From Table 5, it was observed that the value of forecast error per cent varies from the -60.558 per cent to 17.535 per cent. The value of RMSE and MAPE were observed low 887.504 and 20.245, respectively. It was also observed the Theil inequality coefficient was 0.099 which indicated that the predictive performance of the model was good. Thus study revealed that the model AR(6), AR(3), MA(2), MA(13) found fitted well and further forecasted the Keshar mango price (Rs./q) for the year 2020 was computed (Table 6). It was observed that Actual prices were high in start of the season and goes decreasing at end of the season but the forecasted values also showed same trend. Similarly Pardhi *et al.* (2018) made efforts on forecasting the prices of mango using ARIMA model in Varanasi market of Uttar Pradesh.

ALPHONSO

Similar steps were followed as explained above for forecasting prices of Alphonso mango in Valsad district and results were discussed hereunder;

Stationarity check

Table 7 revealed that Augmented Dickey-Fuller (ADF) unit root test statistic at level (no difference) was accepted the null hypothesis i.e. prices data of Alphonso mango has a unit root (non-stationary). The probability value were more than rejection values at 1 per cent level of the significance (*p*-0.0453). The analysis was proceeding further by taking 1st differencing and again tested stationarity. Table 7 showed that at 1st differencing the null hypothesis for test statistic was rejected which indicated prices data of Alphonso mango had stationarity (*p*-0.0000). Therefore ARIMA model identification was proceed with taking value, d= 1.

Identification of the model

The tentative models were first identified based on the Auto-Correlation Function (ACF) and Partial Auto-Correlation Function (PACF) plots shown in Figure 4. Based on numbers of spike outside the confidence level in the correlogram, the all possible combination of the *p* and *q* values were carried out for identification of the best model. The Method of ARMA Maximum Likelihood was applied for model development. The tentatively identified five best models for forecasting prices of Alphonso mango and are presented in Table 8. It also indicated the values of Akaike Information Criteria (AIC) and Schwarz Bayesian Information Criteria (SIC) along with adjusted R^2 and SIGMASQ. Based on the lower the value of AIC, SIC and SIGMASQ with high value of Adjusted R^2 the selected model was stated better for forecasting. From Table 8, it was found that ARIMA (1, 1, 2) was good model for forecasting the prices of the Alphonso mango.

Diagnostic check and estimation of parameters

The residual diagnostics (Correlogram-Q-statistics) was carried out on ARIMA (1, 1, 2) and estimated the coefficients for good forecast model. Table 9 showed that based on residual diagnostics ARIMA (1, 1, 2) model was modified by introducing the variables AR(3) and MA(3) with existing AR(1) and MA(2). The graphical representation of the residuals of the correlogram are shown in Figure 5 (a) & (b).

Validation of model and Forecasting

The validation of the selected model was done based on RMSE, MAPE and Theil inequality coefficient. From Table 10, it was observed that the value of forecast error per cent varies from the 7.575 per cent to 16.653 per cent. The value of RMSE and MAPE were observed low 742.529 and 14.325, respectively. It was also observed the Theil inequality coefficient was 0.079 which indicated that the predictive performance of the model was good. Thus study revealed that the model AR(1), AR(3), MA(2), MA(3) found fitted well and further forecasted the Alphonso mango price (Rs./q) for the year 2020 was computed (Table 11). It was observed that forecasted prices were high in start of the season and goes decreasing, but at end of the season increased upto some extent.

Table 5: Validation of the ARIMA model AR(6), AR(3), MA(2), MA(13)

Week	Actual Price (Rs./q)	Forecasted Price (Rs./q)	Forecast Error (%)
28-04-2019 - 04-05-2019	5220	4888	06.365
05-05-2019 - 11-05-2019	5375	4460	17.018
12-05-2019 - 18-05-2019	5375	4432	17.535
19-05-2019 - 25-05-2019	5000	4778	04.445
26-05-2019 - 01-06-2019	5000	4273	14.535
02-06-2019 - 08-06-2019	4600	4226	08.134
09-06-2019 - 15-06-2019	4300	4128	04.003
16-06-2019 - 22-06-2019	3500	4326	-23.587
23-06-2019 - 29-06-2019	2959	4328	-46.271
30-06-2019 - 06-07-2019	2732	4387	-60.558
RMSE	887.504		
MAE	753.412		
MAPE (%)	20.245		
Theil inequality coefficient	0.099		

Table 6: Forecasted Keshar mango prices (Rs./q) for the year 2020 in Valsad market

Week	Forecasted Price (Rs./q)
30-04-2020 - 06-05-2020	4530
07-05-2020 - 13-05-2020	4508
14-05-2020 - 20-05-2020	4442
21-05-2020 - 27-05-2020	4403
28-05-2020 - 03-06-2020	4440
04-06-2020 - 10-06-2020	4467
11-06-2020 - 17-06-2020	4469
18-06-2020 - 24-06-2020	4504
25-06-2020 - 01-07-2020	4551

Table 7: **Stationarity (ADF) test**

ADF test at level

Null Hypothesis: ALPHONSO_PRICE has a unit root				
Exogenous: Constant				
Lag Length: 2 (Automatic - based on AIC, maxlag=13)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-2.922830	0.0453
Test critical values:	1% level		-3.478547	
	5% level		-2.882590	
	10% level		-2.578074	

ADF test at 1st differencing

Null Hypothesis: D(ALPHONSO_PRICE) has a unit root				
Exogenous: Constant				
Lag Length: 8 (Automatic - based on AIC, maxlag=13)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-6.673096	0.0000
Test critical values:	1% level		-3.481217	
	5% level		-2.883753	
	10% level		-2.578694	

Table 8: Identification of ARIMA model

ARIMA Model →	(1, 1, 2)	(12, 1, 1)	(2, 1, 1)	(11, 1, 1)	(0, 1, 1)
SIGMASQ	264500.300	267311.300	269970.200	271832.800	275623.200
Adjusted R^2	0.169	0.160	0.152	0.146	0.141
AIC	15.390	15.397	15.407	15.415	15.412
SIC	15.478	15.485	15.495	15.503	15.478

Table 9: Estimation of coefficients of the ARIMA model through residual diagnostics

Dependent Variable: D(ALPHONSO_PRICE)				
Method: ARMA Maximum Likelihood (OPG - BHHH)				
Sample: 2 132				
Included observations: 131				
Convergence achieved after 36 iterations				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	18.53893	11.88809	1.559453	0.1214
AR(1)	0.287674	0.073739	3.901220	0.0002
AR(3)	0.095160	0.131689	0.722609	0.4713
MA(2)	-0.417808	0.068186	-6.127502	0.0000
MA(3)	-0.431281	0.106071	-4.065967	0.0001
SIGMASQ	241206.2	28109.93	8.580818	0.0000
R-squared	0.259521	Mean dependent var	17.69589	
Adjusted R-squared	**0.229902**	S.D. dependent var	572.9303	
S.E. of regression	502.7764	**Akaike info criterion**	**15.33201**	
Sum squared resid	31598010	**Schwarz criterion**	**15.46370**	
Log likelihood	-998.2467	Hannan-Quinn criter.	15.38552	
F-statistic	8.761925	Durbin-Watson stat	2.012147	
Prob(F-statistic)	0.000000			

Table 10: Validation of the ARIMA model AR(1), AR(3), MA(2), MA(3)

Week	Actual Price (Rs./q)	Forecasted Price (Rs./q)	Forecast Error (%)
28-04-2019 - 04-05-2019	4728	4370	7.575
05-05-2019 - 11-05-2019	5000	4256	14.885
12-05-2019 - 18-05-2019	5000	4277	14.461
19-05-2019 - 25-05-2019	5125	4311	15.876
26-05-2019 - 01-06-2019	5125	4322	15.672
02-06-2019 - 08-06-2019	5050	4338	14.094
09-06-2019 - 15-06-2019	5150	4358	15.384
16-06-2019 - 22-06-2019	5250	4376	16.653
23-06-2019 - 29-06-2019	--	4394	--
RMSE	742.529		
MAE	727.575		
MAPE	14.325		
Theil inequality coefficient	0.079		

Table 11: Forecasted Alphonso mango prices (Rs./q) for the year 2020 in Valsad market

Week	Forecasted Price (Rs./q)
30-04-2020 - 06-05-2020	4976
07-05-2020 - 13-05-2020	4901
14-05-2020 - 20-05-2020	4880
21-05-2020 - 27-05-2020	4870
28-05-2020 - 03-06-2020	4871
04-06-2020 - 10-06-2020	4881
11-06-2020 - 17-06-2020	4894
18-06-2020 - 24-06-2020	4910
25-06-2020 - 01-07-2020	4927

As discussed above Pardhi *et al.* (2017) used similar approach of ARIMA for price forecasting of mango in Lucknow of Uttar Pradesh. Areef *et al.* (2020) to studied price behaviour and forecasting of onion prices in Kurnoo market by applying ARIMA approach. Similarly ARIMA model methodology was adopted by Pardhi *et al.* (2018) for forecasting the prices of mango for Varanasi market of Uttar Pradesh. Time series forecasts are almost accurate and take less effort in execution. No model is permanent to forecast the area, productivity and prices, therefore it needs update timely in frequent interval. In the current study ARIMA models to forecast prices were limited to available data for specific market.

Conclusion

Based on the current study it is anticipated that the identification of the best forecast model may help to the producers, consumers as well as dealers in making right decisions during marketing of these produces. The scientist or researcher can make their forecasts more valuable in concerned to demand, policy making, export etc. only when the challenge is to figure out how to get it, and what they need to do to acquire and use forecast. The present study was carried out to develop forecasting models for area (ha), productivity (mt ha^{-1}) and also forecasting the prices (Rs/q.) of Mango (Keshar and Alphonso) in Valsad district of south Gujarat. The forecast value of mango indicated an increasing trend of prices in selected market of Valsad. For getting better prices it needs a specialised marketing infrastructure, spatial market intelligence and post-harvest loss reduction technology.

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Conflict of interest

The authors declare that they have no conflict of interest.

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