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FORECASTING FOR AGRICULTURAL PRODUCTION USING ARIMA MODEL

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Abstract:
Paddy is a most important food crop in India moreover second most in over world. ARIMA is one of the most valuable forecasting techniques in prediction to the future events in time series analysis. This data was collected from Ministry of Agriculture & Farmers Welfare, Government of India. The ARIMA (Box-Jenkins) model was used for paddy production forecast from south India. The concert of fitted ARIMA model used for Andhra Pradesh, Karnataka, Kerala and Tamil Nadu, ARIMA(0,1,1), ARIMA(0,1,1), ARIMA(0,1,2) and ARIMA(0,1,1). Examine through compute the various Parameter estimate measures BIC, RMSE, MAPE, MAE, MaxAPE and MaxAE are used. The main objective of this work is designing and implementation of time series model for crop production with the comparison of each and every state to verify this result.

Introduction:

India is one of the largest farming manufacture producers around the globe. The Paddy crop is one of the main and important grains of India and it was the most part grown in rain fed area. ARIMA is one of the most valuable forecasting techniques in prediction to the future events in time series analysis. In Agriculture, production forecasting for a lead year is foremost to crop planning and agro based resource utilization and overall management of production crop. In many researchers were used for time series model to handle agricultural forecasting problems.Rice is among the three leading food crops of the world, with maize and wheat being the other two and it is one of the most important cereal crop of India occupying an area of 43.39 million hectare with an annual production of 104.32 million tones with an average productivity of 2404 kg/ha (2015-16), Hemavathi et al., (2018) was discussed. India is the second biggest producer and consumer of rice and accounts for 22.3% of total production (2015-16).It takes care of more than 50% of the total populace. It is the staple food of the majority of the individuals in South East Asia. Asia represents around 90% of the world's paddy development and creation Rani et al., (2014). Among the paddy developing nations, India has the biggest zone under development, however regarding volume of yield, it is underdog to China.It makes up 42 percent of India's complete food grain creation and 45 percent of the total cereal produced in the nation.

Being a major paddy producing country in world, presentstudy is aimed to forecastthe paddyproduction of majorproducing states of India.Hemavathi et al., (2018)have reported ARIMA model for forecasting of area, production and productivity of rice and it's growth status in Thanjavur district.D. Ashwini et al., (2017) have used time series forecasting model for comparison of Paddy Prices in India from several states. K.K. Suresh et al., (2011) have used to ARMA models for Forecastingfor sugarcane yield of Tamilnadu. Singh et al., (2007) have applied statistical models for rice production forecasting in India.

Kerala is still depending on its neighbouring states, particularly Tamil Nadu and Andhra Pradesh to meet its daily needs of food items. According to the report of agriculture department of Kerala (2001) 68 percent of vegetables traded in the state are produced in Tamilnadu and Karnataka. P. Maneesh et al.,(2016) have discussed thehigh demand for export make Kerala more inclined to cultivating spices and rubber which yield more money to farmers from limited land area. Rice and vegetables are available at lower costs in neighboring states than it producing in Kerala. Therefore, number of full time farmers is reduced and gradually many more agriculture lands are converted for non agriculture purpose.Under these circumstances a review of the changing agricultural production trend in Kerala is necessary to give some insights to the emerging tendencies in relation to food.N. Karunakaran(2014) has analyzed the trends anddeterminants of paddy cultivation in Kerala and theeffects on food security.SourabhShastri et al.,(2018) have discussed the Forecasting withExponential Smoothing Method.

In this paper investigation, we applied Autoregressive Integrated Moving Average (ARIMA) forecasting model for time series data. The paper is organized as follows from five sections: Section.2 Materials and Methods to the analysis of test procedure. Section.3Exponential Smoothing Method,Section 4.Results and Discussion,Finally Conclusionsin Section 5.

2. MATERIALS AND METHODS

2.1. Data Description

The yearly rice production data, in Thousand tones from the year 1981to 2009 for South states in Indian(Andhra Pradesh, Karnataka, Kerala and Tamil Nadu).As per availability the time series data related to the yearly rice productions data collected from Ministry of Agriculture & Farmers Welfare, Government of India.

2.2. Auto Regressive Integrated Moving Average (ARIMA) Model

The ARIMA model analyzes and forecasts equally spacedunivariate time series data.An ARIMA model predicts avalue in a response time series as a linear combinationof its own past values. The ARIMA approach was firstpopularized by Box and Jenkins (1976), and ARIMAmodels are often referred to as Box-Jenkins models. This process is referred as ARIMA (p, d, q), where p and q refer to the number ofAR and MA terms, and d refers to the order of differencing required for making the series a stationary.Cooray (2008) has proposed a flow chart for the forecasting procedure and it is shown below in figure 1.

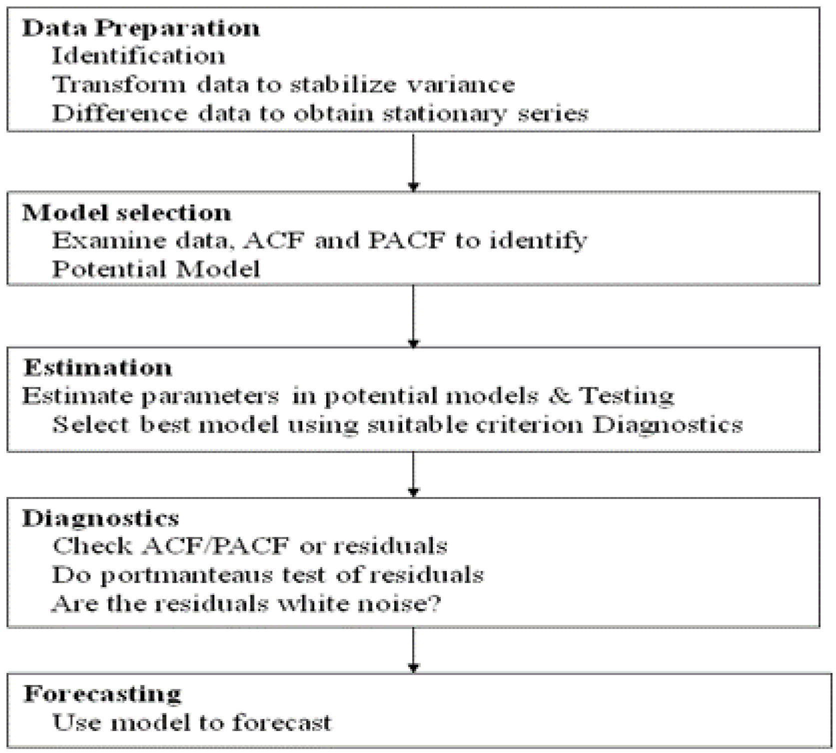

Figure 1: Forecasting Procedure ofARIMA Model

3. **Experiment andAnalysis for Exponential Smoothing Method**

Exponential smoothing is one of the fixed-model time arrangement forecast techniques. It was at first called as “exponentially weighted moving average". Exponential smoothing is a plan of forecast that utilizations weighted estimations of before succession perceptions to figure future qualities. It designates the most extreme load to the most recent perception and the weight decrease in a coordinated manner as more established and more seasoned perceptions are incorporated.

The proposition of exponential smoothing is to smooth the first grouping and afterward utilize the smoothed succession to foresee impending estimations of the variable of concern. This cycle is for the most part accommodating when the boundaries relating the time arrangement are changing slowly over the long haul. Exponential smoothing strategy for expectation utilizes weighted normal of past perceptions to foresee forthcoming qualities. This technique is helpful for anticipating arrangement that uncover pattern, irregularity or both.

Table 1:Fitted exponential smoothing model for rice production

Sl. No	States	RMSE	MAPE	MAE	MaxAPE	MaxAE
1	Andhra Pradesh	1440.514	11.722	1080.268	53.640	3930.206
2	Karnataka	573.527	11.527	345.761	51.038	2121.238
3	Kerala	141.681	16.824	71.586	323.754	674.056
4	Tamil Nadu	1490.387	26.625	1133.357	213.02 5	4055.579

Several methods of error estimation have been considered. The table 1.Shows that Parameter estimates of the various fittedexponential smoothing model for rice production in south India states like Andhra Pradesh, Karnataka, Kerala and Tamil Nadu.The accuracy of the fitted models is identified through the Root Mean Square Error (RMSE), Mean Absolute Percentage Error (MAPE), Mean Absolute Error (MAE), Maximum Absolute Percentage Error (MaxAPE) and Maximum Absolute Error (MaxAE).

Table 2:Forecasting Values of rice production in exponential smoothing model

Sl. No	Forecasted Year	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu
1	2010	12273.79	4019.78	475.85	5573.80
2	2011	12448.12	4089.81	446.82	5596.46
3	2012	12622.46	4159.84	417.79	5619.13
4	2013	12796.80	4229.87	388.75	5641.81
5	2014	12971.14	4299.90	359.72	5664.50
6	2015	13145.48	4369.93	330.69	5687.20
7	2016	13319.82	4439.96	301.65	5709.91
8	2017	13494.16	4509.99	272.62	5732.64
9	2018	13668.50	4580.02	243.59	5755.37
10	2019	13842.84	4650.05	214.56	5778.12

4. RESULTS AND DISCUSSION

This study is based on secondary data of rice production in south states Andhra Pradesh, Karnataka, Kerala and Tamil Nadu from India. The collected from the four states from 1981 to 2009.The table3.Shows that the descriptive measures of rice productions for south states the amount of yearly rice productions for South States ranges between 1339.70 in thousand tons to 6591.50 in thousand tons. The mean and standard deviation of rice productions in Andhra Pradesh is 9594.9241and 2014.35424which is high among the south states and lowest value in Kerala. The value of skewness indicates that the rice productions follow negatively skewed distribution.

Table 3:Summary Statistics of rice production in south India

Sl. No	Descriptive	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu
1	Sum	278252.80	86137.10	26200.30	162182.40
2	Mean	9594.9241	2970.2448	903.4586	5592.4966
3	Median	9276.7000	3023.9000	975.1000	5590.0000
4	Mode	6591.50	1894.70	208.20	1903.80
5	Standard Deviation	2014.35424	805.11780	281.11058	1429.30637
6	Variance	4057622.990	648214.673	79023.156	2042916.700
7	Maximum	14241.00	5744.00	1339.70	8141.40
8	Minimum	6591.50	1894.70	208.20	1903.80
9	Range	7649.50	3849.30	1131.50	6237.60
10	Skewness	.488	1.389	-.370	-.524
11	Kurtosis	-.396	3.571	-.424	.356

4. 1Identification

For forecasting rice production yield, ARIMA model estimated only after transforming the variable under forecasting into a stationary series. The stationary series is the individual whose value varies over time only around a constant mean and constant variation. There are several ways to ascertain this. The most well-known technique is to check stationarity through examining at the chart or time plot of the information is non-stationary. In this case graph of X_t was stationary in mean and so no need of differencing the data.

Model identification involves, finding out the order of the AR, MA parameters and differentiation value of themodel, first we check if the series is stationary or not, if the series is non stationary we have to switchover for differences in the serieswhich is given in figure 2.

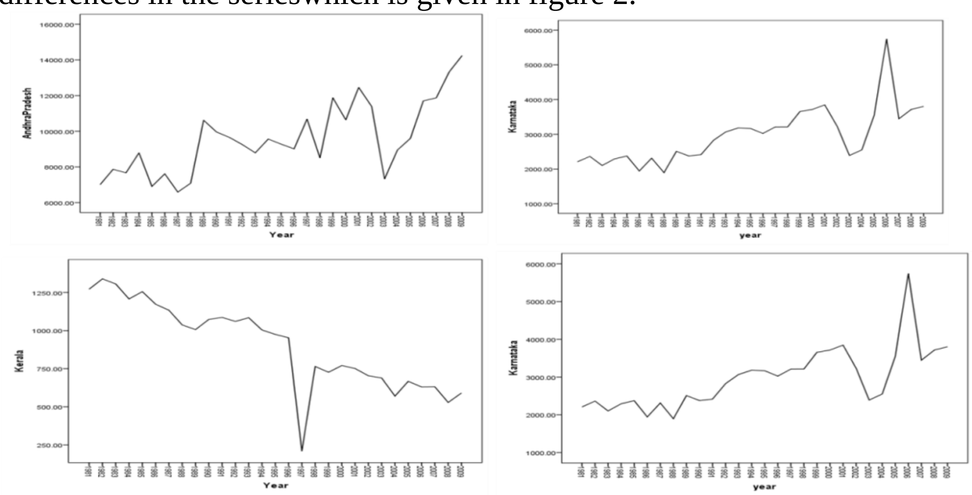

Figure 2:Original data for *Andhra Pradesh, Karnataka, Kerala and Tamil Nadu*

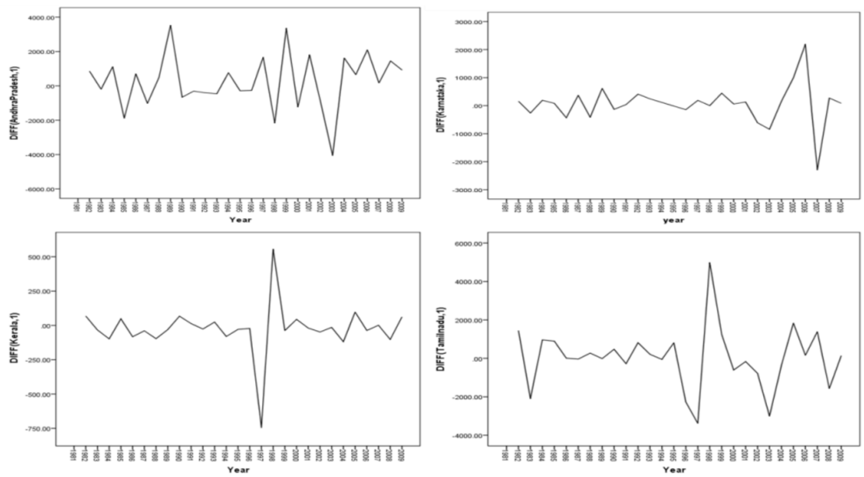

Figure 3:Differenced series for rice productions

At first, the stationarity of the time series is observed using the time plot figure 3. The observations fluctuate horizontally and the pattern of fluctuation shows, the time series has a constant in mean and non-seasonality pattern is also identified from the plot. Some of the spikes highly deviated from the center.

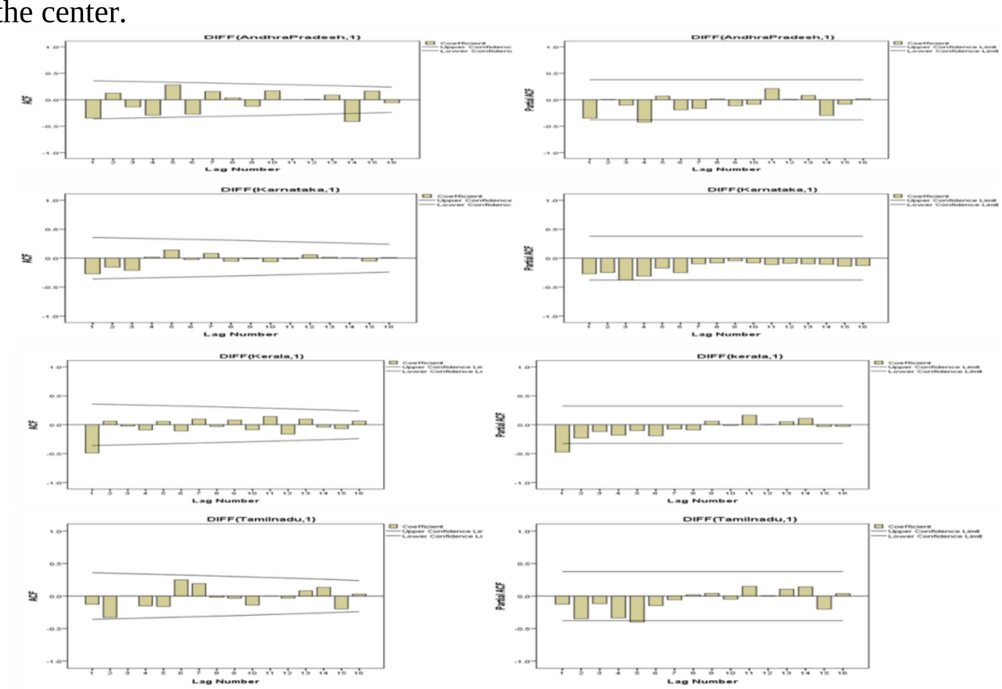

Figure 4:ACF and PACF of fitted for first order differencein rice productions

In the first step, we examined whether there exists correlation among the observations in the time series. The values of ACF at time lags from 1 through 16 are computed which are presented in figure 4. Hence, it is inferred that there is a strong evidence for the presence of autocorrelation among the rice productions in South States. The appropriate time series model could be either AR or ARMA model.

4. 2 ParameterEstimation

After identifying the appropriate ARIMA (p, d, q)'s structure, successive steps of parameter inference and testing were performed.Estimation stage comprises of utilizing the information to gauge and make inductions about the boundaries of probably recognized model. The boundaries are assessed with the end goal that a general proportion of residuals are limited. The last phase of model structure is the trying or demonstrative checking of model ampleness. In the wake of distinguishing the provisional model, the cycle is again trailed by the phase of boundary assessment and model confirmation. Demonstrative data may assist with proposing elective model(s). Presently, the arrangement is fixed and a few models were chosen dependent on their capacity of dependability forecast.On examining its autocorrelation functions (ACF), partial autocorrelation functions (PACF), on the basis of minimum normalized BIC Values significance of AR and MA parameters, the ARIMA model was selected.

Table4: BIC Values for Different ARIMA Model

Sl.No	Model Type	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu
1	ARIMA(0,1,0)	16.096	14.393	11.865	15.741
2	ARIMA(1,1,0)	15.641	14.205	11.400	15.742
3	ARIMA(0,1,1)	15.352*	13.691*	11.044	15.242*
4	ARIMA(1,1,1)	15.380	13.789	11.008	15.397
5	ARIMA(0,1,2)	15.373	13.726	10.989*	15.411
6	ARIMA(2,1,0)	15.682	14.226	11.307	15.649
7	ARIMA(1,1,2)	15.550	13.991	11.178	15.555
8	ARIMA(2,1,1)	15.546	13.907	11.156	15.452
9	ARIMA(2,1,2)	15.648	14.112	11.318	15.642

The minimum normalized BIC value of the model ARIMA(0,1,1), ARIMA(0,1,1), ARIMA(0,1,2) and ARIMA(0,1,1) in this ARIMA model is selected from the Andhra Pradesh, Karnataka, Kerala and Tamil Nadu and its indicated in symbol * its displayed in the Table.4.

Table 5:Parameter estimates of the fitted ARIMA model for rice production

Sl.No	States	RMSE	MAPE	MAE	MaxAPE	MaxAE
1	Andhra Pradesh	1557.949	11.639	1082.185	65.081	4768.515
2	Karnataka	588.864	12.066	364.802	49.784	2022.968
3	Kerala	147.761	16.875	73.198	350.032	350.032
4	Tamil Nadu	1549.357	27.404	1149.331	226.840	4318.572

Several methods of error estimation have been considered at the Table 5.Shows that Parameter estimates of the various fitted ARIMA models for rice production in south India states likeAndhra Pradesh, Karnataka, Kerala and Tamil Nadu.The accuracy of the fitted models is identified through the RMSE, MAPE, MAE, MaxAPEand MaxAE.

4. 3Diagnostics Checking

The models are estimated and they are acceptable only when, the residuals are random. For this purpose, more than a few alternative models that may be appropriate were to be fitted. The ACF and PACF of the residuals of this model are then estimated. If the plot of these ACF and PACF exhibit non-significant pattern, then the corresponding model is considered as valid and can be considered for forecasting. Figure 5. shows that the residuals of ACF and PACF for ARIMA(0,1,1), ARIMA(0,1,1), ARIMA(0,1,2) and ARIMA(0,1,1) from Andhra Pradesh, Karnataka, Kerala and Tamil Nadu, respectively and its exhibit a non-significant pattern, this model is consider as valid and can be consider for forecasting.

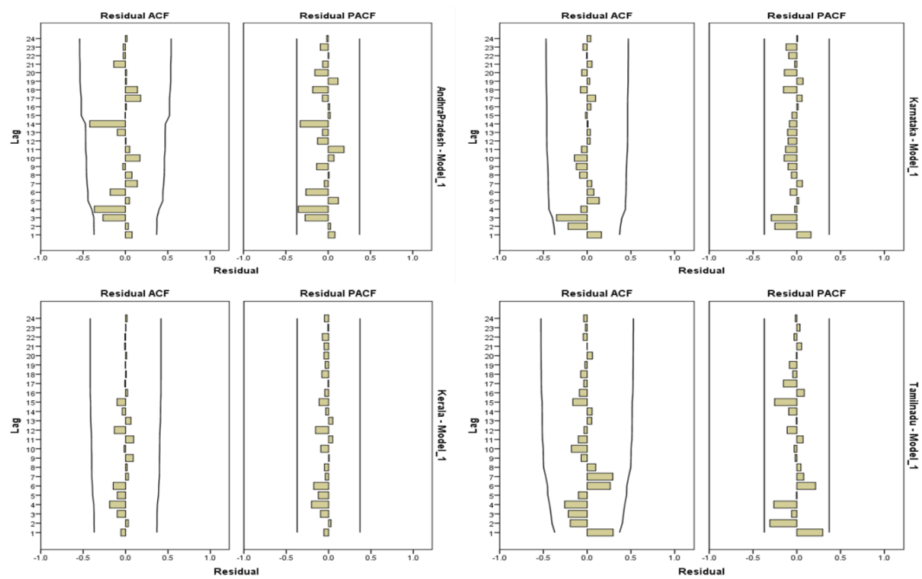

Figure 5:ACF and PACF of the Residuals of Fitted ARIMA Model

4.5Forecasting

The ten years of forecasted results for rice production are shown in the Table. 4. and the forecast indicates that there are narrow variations in between the actual and forecasted values of rice production in the selected states. This forecast is based on past data and model that actual productions data may not turn out to be the same as forecasted. From the forecasted values identified that the rice productions trend also increasing and decreasing in the future years.

Table 6:Forecasting Values of Rice Production

Sl. No	Forecasted Year	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu
1	2010	14083.53	4106.84	522.46	5573.80
2	2011	14534.96	4194.62	498.34	5596.46
3	2012	15001.13	4283.56	479.77	5619.13
4	2013	15482.03	4373.66	461.83	5641.81
5	2014	15977.66	4464.92	444.53	5664.50
6	2015	16488.01	4557.34	427.85	5687.20
7	2016	17013.09	4650.92	411.81	5709.91
8	2017	17552.91	4745.66	396.40	5732.64
9	2018	18107.45	4841.57	381.62	5755.37
10	2019	18676.72	4938.64	367.47	5778.12

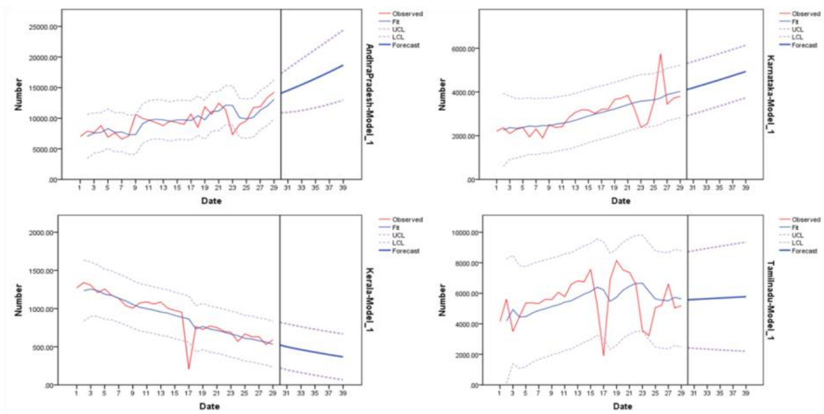

Figure 6:Rice Production Actual and Forecasted Data in Thousand Tonnes for the Year 1981 to 2019.

5. Conclusions

Forecasting is a more important problem in the fields of business and industry, economics, medicine, finance and etc..and it's used for planning and decision making. In this study, we have computed the rice productions in Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and it's compared with each and every state. The predicted values are nearest to the actual values and some of the forecasting values are the more nearest to the actual values fromFigure 7. Rice production of Kerala forecasting trend is decreasing as compared with others three states Andhra Pradesh, Karnataka and Tamil Nadu. Rice production of Andhra Pradesh forecasting shows high increasing trend and increasing trend also identified with Karnataka and Tamil Nadu state alsofrom Figure 6. This model verified with the available observed data with the forecasted form 2010 to 2019, the available observed value is almost nearest to the forecasted value from exponential smoothing. The advantage of this method given better accuracy in RMSE, MAPE, MAE, MaxAPE and MaxAE error comparing with exponential smoothing and ARIMA. This model forecasted production revealed an increase in the prices of rice in the future years and also demand for the crop. Hence, increase in the area of production of paddy and their sale in the suitable markets can be planned suitably.

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