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FORECASTING AREA AND YIELD FOR MAIZE CROP OF PUNJAB, PAKISTAN FOR 2021-2030

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ABSTRACT

This study attempts to forecast area and yield for maize crop of Punjab by using Auto Regressive Integrated Moving Average (ARIMA) models. Using the time series data for the year 1948 to 2020, area and yield for maize crop were forecasted for 10 years starting from 2021 to 2030. ARIMA (0.1.0) and ARIMA (1.1.0) were found to be the best model for area and yield of maize crop respectively. Some diagnostics tests were also performed on fitted models and found well fitted. Forecasted area and yield will increase for the year 2021 to 2030.

INTRODUCTION

Agriculture is vital role to any country's overall growth, so it must be developed. For example, farmers contribute for roughly 19 percent of Pakistan's total GDP. This percentage alone indicates that Pakistan is a highly developed country. Because agriculture takes up such a large quantity of area, the country is reliant on it. Maize is one of the most widely grown crops. It is one of the world's most important cereal crops, and it helps to ensure food security in the majority of poor countries. It's cultivated in more than 70 nations throughout the world. The top maize-producing nations are:

The United States of America, China, Brazil, Mexico, Indonesia, India, France, and Argentina are among the countries involved. In Pakistan, maize is at third position by area, after wheat and rice. Maize is an important crop in Pakistan for human consumption, poultry feed, and livestock fodder, as well as a raw material for industry. Prussic acid, oxalic acid, and ergot toxicity are not present in maize fodder at any stage of plant development. Maize is the most suited crop for silage and is known as the "King of Silage Crops." It is cultivated on 0.974 million hectares for grain production, yielding 3.707 million tons of grain per year with an average yield of 3805 kg/ha.

Maize is primarily a rainfedkharif crop that is planted shortly before the monsoon arrives and harvested once the monsoon has passed. Despite this, Pakistan corn yields are much lower than those of other major corn-producing countries. Increased acreage under hybrids, adoption of stronger genetics, and enhanced agronomic practices all have the potential to boost Pakistan's maize production significantly. As maize crop is most important crop for cereal production. By keeping this importance in view there is need to forecast yield and cultivation area of maize crop in Punjab. Government needs correct facts and figures about area and production of major crops in advance for policy making.

Many studies have made significant progress in estimating the acreage and yield of wheat and rice crops, while maize forecasting has received only minor attention. Previously, a number of crop forecasting models were developed. A few of them are by Azhar et al. (1973), Amir & Akhtar (1984), Sher and Ahmad (2008) for wheat crop and Khan and Khan (1988), Maria and Tahir (2011) for rice crop, Maqsood et al. (2004) for sugarcane crop, Badmus and Ariyo (2011) and Tahir and Habib (2013) for maize crop.

Number of researchers has done work to forecast the area and production of different major crops like Wheat and Rice. Many researchers used ARIMA model for forecast area and Yield for different crops. Sharma et al. (2018) forecasted the area and production of maize crop in Nigeria by using the ARIMA model. Verma, S. (2018) used modelling and forecasting maize yield in India using ARIMA and State Space Models. But little work has done on forecasting of yield and production of maize crop in Punjab province of Pakistan. Our main focus in this paper is forecast the yield and area of maize crop in Punjab by using the ARIMA time Series model. Esther, N & Magdaline, N (2017) diagnosed by plotting ACF and PACF of the residual of best fit model, that was ARIMA (1,1,2) to check the autocorrelation in the error terms. They reveal that ARIMA (1,1,2) was the best model to forecast pulses (lentils) yield in Kenya. They predicted the lentil yield by using the ARIMA model in Kenya. Badmus & Ariyo (2011) forecasted the area and production of maize crop in the country Nigeria by using the ARIMA (1,1,1) and (2,1,2) models. Ramesh et al. (2014) found the most suitable ARIMA model for maize yields that was ARIMA (1,1,0).

METHODOLOGY

Modeling and forecasting of agriculture commodities have traditionally been carried out by using various econometric modeling techniques. The reason for using ARIMA model is that ARIMA is the most general class of forecasting models.

Data Analysis Strategy:

Data was collected by Crop Reporting Service for the period of 1948-2020. The software SPSS ver. 26 was used to analyze the time series data. ARIMA model by employing Box- Jenkins methodology was used for forecasting.

ARIMA:

The autoregressive integrated moving average [ARIMA] model is one of the most well-known and extensively utilized models. This model combines the autoregressive and moving average models into one. In nature, time series are frequently non-stationary. To get a stationary time series, we must use the differencing term d. to convert a non-stationary series to a stationary one. As a result, the ARIMA model is the generic version of the ARMA model (p,d,q).

In the ARIMA model, P represents the order of the autoregressive term, d represents the order of the differentiating term, and q represents the order of the moving average term.

$$\Delta^d z_t = (a_1 y_{t-1} + \cdots + a_m y_{t-m} + e_t + \beta_1 e_{t-1} + \beta_2 e_{t-2} + \cdots + \beta_n e_{t-n}).$$

Box-Jenkins Approach:

The Box-Jenkins methodology is extensively used for univariate time series modeling and is recognized as the most successful forecasting tool. It is utilized in planning and prediction. The Box-Jenkins methodology differs from others in that it selects the best predictive model based on the previous behavior of a variable. It is thought that any time series model may be represented by one of these three types of models. The Box-Jenkins approach is used to estimate and predict the univariate time-series model. Only stationary data may be used with this approach.

The steps for Box Jenkins are as follows:

- Identification of model
- Estimation of parameters
- Diagnostic checking
- Forecasting

Autoregressive models (AR): basis of forecasting is linear function of variable's past values.

Moving Average models (MA): basis of forecasts is linear combination of past errors.

Autoregressive-Moving Average models (ARMA): combination of both categories.

RESULTS AND DISCUSSION

Identification of Time Series Model for Maize Crop:

The first step in identifying the perfect model is to find out the trend and stationery of data which can be assessed from the squence chart and correlogram .The sequence chart of maize area and yield (original series) as depicted in Figure 1 and Figure 2 respectively which are indicated that the area and yield of maize crop show the increasing trend over the years and thus indicated non–stationary of data. For making the stationary, there is need to taken the regular first differnce.

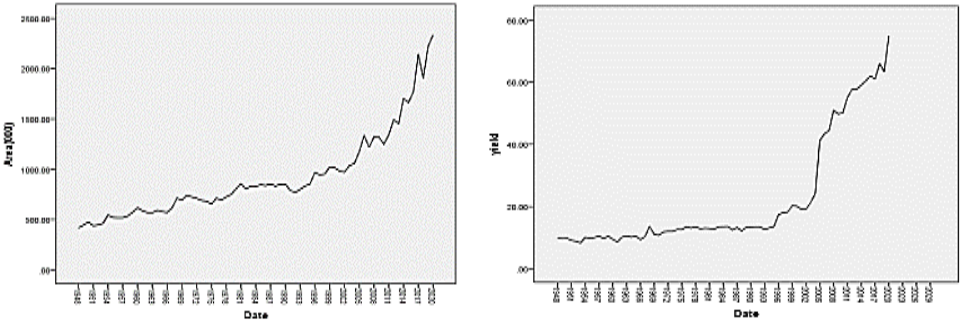

Figure 1: Line Diagram of Maize Area (000) and Yield in Punjab (Original Series)

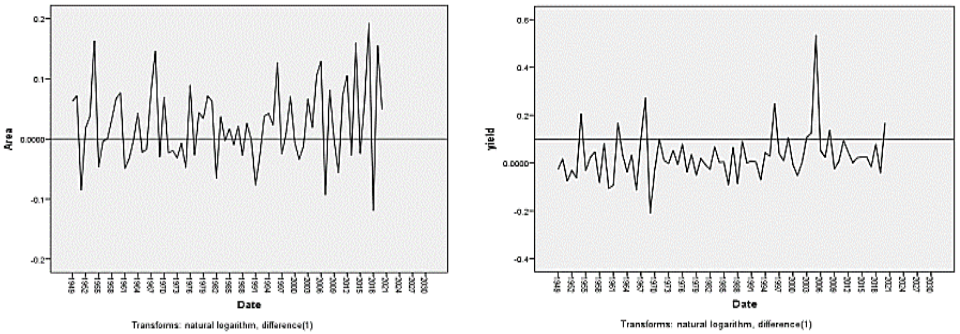

Figure 2: Line Diagram of Maize Area and Yield in Punjab after 1st Difference

After taking the first difference, Figure 3 and Figure 4 indicate after the first difference, the series become stationary for area and yield of maize crop in Punjab respectively. Thus, the value of d was fixed as 1. In order to identify the order of Autoregressive (AR) for the value 'p' and 'the order of Moving Average 'MA' for the value of q. Correlograms of autocorrelation functions (ACF) and partial autocorrelation functions (PACF), respectively were examined. The correlogram of autocorrelation function (ACF) of differenced series (Figure 3) indicates that the auto correlation function falls immediately after one lag, hence the value of 'q' was decided to be '0'. Further, the correlogram of partial autocorrelation function (PACF) of differenced series (Figure 3) indicates that the auto correlation function falls immediately after one lag, hence the value of 'p' was decided to be '0'. Thus, the ARIMA (0,1,0) model may be selected for parameter estimation, model validation and forecasting of maize Areain Punjab. The correlogram of autocorrelation function (ACF) and partial autocorrelation function (PACF) of differenced series (Figure 3) indicates that the auto correlation function and partial autocorrelation function has one lag significant'. Thus, the ARIMA (1,1,0) model may be selected for parameter estimation, model validation and forecasting of maize Area in Punjab. The use of other diagnostics such as large value of R^2, minimum value of MAPE &Normalized BIC, significance of AR and MA parameters also confirms the selection of the ARIMA (0,1,0) and ARIMA (1,1,0) model for maize area and yield in Punjab respectively (Table 2).

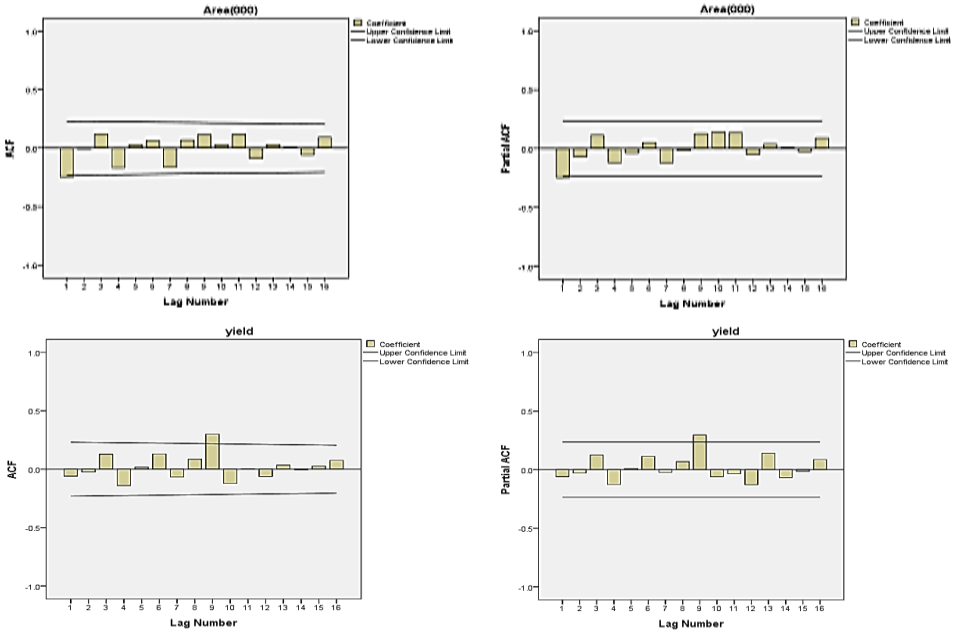

Figure 3: Correlograms of ACF and PACF of Differenced Series for maize Area and Yield in Punjab Pakistan

Table 1
ARIMA Models Fitted for Time Series Data of Maize Area and Yield and Corresponding Selection Criteria, i.e. R2, MAPE and Normalized BIC

Parameter	Model	R2	MAPE	Normalized BIC
Area	**(1,1,1)**	**0.977**	**4.756**	**8.649**
	(0,1,0)	0.977	4.833	8.498
	(0,1,1)	0.977	4.749	8.551
	(1,1,0)	0.978	4.758	8.547
Yield	**(1,1,0)**	**0.992**	**4.235**	**1.449**
	(1,1,1)	0.627	4.601	1.515
	(0,1,1)	0.991	4.625	1.465
	(0,1,0)	0.99	4.995	1.501

Parameter Estimates for Maize Area and Yield in Punjab:

After identifying the suitable ARIMA (0, 1, 0) and ARIMA (1, 1, 0) for area and yield of maize crop in Punjab, the parameters of identified model were assessed and are presented in Table 2.

Table 2
Estimates of ARIMA (2,1,0) Model for Maize Production in India

	Model		Estimate	Standard Error	Sig.
Area	ARIMA (0,1,0)	Constant	0.024***	0.007	0.001
		Difference	1	0	0
		MA lag 1			
Yield	ARIMA (1,1,0)	Constant	0.016***	0.005	0.002
		Difference	1	0	0
		AR lag 1	-0.435***	0.122	0.001

***significant at 1% level; **significant at 5% level.

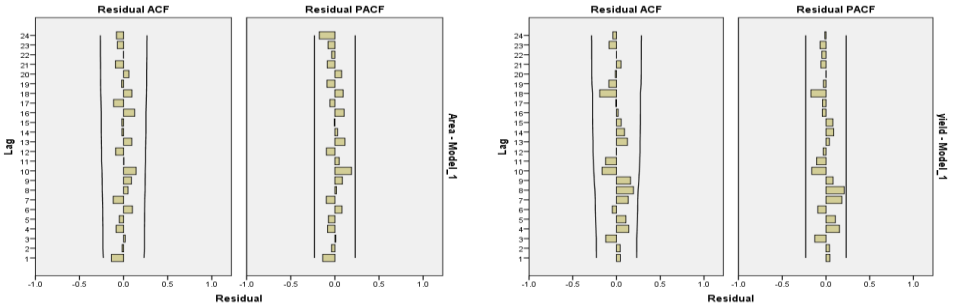

Figure 4: Residual Plots (Correlograms) of ACF and PACF for Identified ARIMA model (2, 1, 0)

Model Diagnostics:

The goodness of fit for the identified model was checked by plotting the residuals any systematic pattern, as shown in Figure 4. As the time series plots of ACF and PACF of the residuals of fitted ARIMA (0,1,0) model and ARIMA (1,1,0) model, exhibited a non-significant pattern, the given models were considered as valid for forecasting.

Forecast of Maize Area and Yield in Punjab:

After the model identification, estimation of its parameters and diagnostic checks, the forecasting of was made to know the future values of maize area and yield in Punjab by using the selected and fitted ARIMA (0,1,0) model and ARIMA (1,1,0) respectively. The forecasted values of maize area and yield in Punjab for the year 2021 to 2030 are presented in Table 4.

Table 4
Forecasting of Maize area and Yield with Confidence Intervals

	Years	Forecast	95% Lower Confidence Limit	95% Upper Confidence Limit
Area (000)	2021	2396.29	2122.69	2695.48
	2022	2458.73	2069.14	2900.78
	2023	2522.79	2040.30	3085.99
	2024	2588.53	2023.89	3263.53
	2025	2655.97	2015.27	3438.15
	2026	2725.18	2012.12	3612.34
	2027	2796.18	2013.10	3787.58
	2028	2869.04	2017.35	3964.88
	2029	2943.79	2024.29	4144.98
	2030	3020.50	2033.51	4328.45
Yield	2021	71.38	63.26	80.27
	2022	74.71	65.01	85.46
	2023	75.07	63.53	88.12
	2024	76.78	63.73	91.73
	2025	77.93	63.44	94.76
	2026	79.36	63.51	98.00
	2027	80.69	63.53	101.11
	2028	82.11	63.67	104.27
	2029	83.52	63.84	107.43
	2030	84.97	64.06	110.81

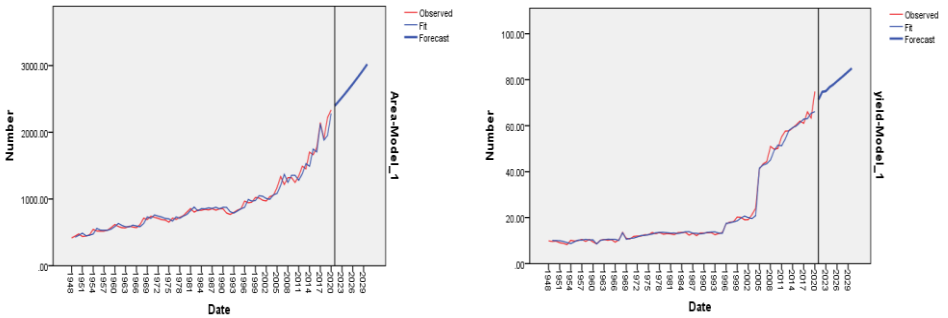

Figure 5: Predicted, Actual & Forecasted Values of Maize Area & Yield in Punjab

CONCLUSION

The Autoregressive integrated moving average (ARIMA) model is considered to be one of the best models when the data consists if at least 50 observations. The present study attempts at modeling and forecasting of maize area and yield in Punjab was done using Autoregressive integrated moving average (ARIMA) model. Autocorrelation function (ACF) and partial autocorrelation function (PACF) functions were estimated, which led to the identification and construction of ARIMA model. The best ARIMA

(0,1,0) model and ARIMA (1,1,0) model for maize area and yield in Punjab the fitted model indicated an increase in maize area in the next ten years from 23,96,290 in the year 2021 to 30,20500 in the year 2030 and similarly maize yield in the next ten years from 71.38 in the year 2021 to 84.97 in the year 2030.

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