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FORECASTING WHEAT PRODUCTION USING TIME SERIES MODELS IN PAKISTAN

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ABSTRACT

The present paper was designed to forecast wheat production for 2017-18, 2018-19 and 2019-2020 respectively by using time series data from 1971-72 to 2016-17 with best selected time series models. Linear, Quadratic, Exponential, S-Curve, Double Exponential Smoothing, Single exponential smoothing, Moving average and ARIMA were estimated for wheat production. The results showed a mix trend in production of wheat for selected time period. ARIMA (2,1,2) was found best one keeping in view close forecasts with actual reported wheat production. So the preference inclined towards the ARIMA (2,1,2) than quadratic to forecasts of wheat production.

Contribution/ Originality

The present study focused on forecasting of wheat production in Pakistan by using various time series models. Keeping in view the close forecast values of production with previous years, ARIMA model was found to be appropriate. Data used in the present study is of different time period.

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1. INTRODUCTION

Forecasting techniques are extensively used for estimation of area, production and yield of major as well as minor crops with climatic data. Estimates are essential before sowing of crop especially for the Government to determine its targets regarding procurement, export and storage of wheat. For this purpose, time series techniques can be used for area, production and yield forecasting relying only on past historical data on area, production and yield of respective crop. Traditionally, analytical techniques namely linear trend, quadratic trend, simple exponential smoothing, double exponential smoothing, simple moving averaging, double moving averaging and ARIMA have already been exercised to forecasts of wheat area and production in Pakistan for different periods.

Wheat is among major crops of rabi* season and basic food for Pakistani people. Wheat crop contributes 9.6 percent of the value added in agriculture and 1.9 percent of GDP of Pakistan. During 2016-17 the area of wheat was 9052 thousand hectares with a decline of 1.9 percent as compared to area of last year which was 9224. The estimates of wheat production were 25.750 million tonnes in 2016 which was 0.5 percent higher than previous year wheat production that is 25.633 million tonnes. The rise in wheat production was due to better use of agricultural inputs ([Economic Survey of Pakistan, 2016-17](#)).

Forecasting is the significant tool for crop production in any country due to which the quantity of produce can be assessed well in time. Reliable agricultural statistics provide a sound basis for agricultural planning and also serve as a yardstick to measure the progress of agriculture ([Amin et al., 2014](#)).

The importance of forecasting techniques in agriculture with regards to production/yield, area of crops and sign of occurrence of crop pests and diseases ([Ramasubramanianv, 2009](#)). Forecasts that are made well timed before harvest of crop are useful for planning the policies related to storage, distribution, pricing, marketing, import-export etc. ([Ranjana, 2010](#)). Review of literature has shown a lot of studies about forecasting techniques in agricultural research such as barley ([Naheed et al., 2015](#)), Major pulses and their price assessment in Pakistan ([Rani and Raza, 2012](#)) trend analysis of tea import ([Raza et al., 2015](#)) forecasting wheat and rice prices in Pakistan ([Abbasi et al., 2015](#)). In another study by ([Ahmad et al., 2017](#)) forecast of area, production and yield of major crops have been made by using time series models This study is focused on two main objectives. First to apply different linear, nonlinear and time series models to data and second to forecast the production of wheat crop in Pakistan by using best fitted model.

2. MATERIAL AND METHODS

Time series data on wheat production for the period 1971-72 to 2016-2017 was taken from government publications such as Agricultural Statistics of Pakistan and Pakistan Economic Survey. Trend analysis and time series models including Linear, Quadratic, Exponential, S-Curve, Double Exponential Smoothing, Single exponential smoothing, Moving average and ARIMA were estimated using MINITAB computer package Version 18 (Statistical Data analysis Software). Data on wheat production from 1971-72 to 2016-2017 was used to forecast wheat production for 2017-18, 2018-19 and 2019-2020 respectively by using best one selected time series models. The general forms of the above models are given in (Table 1).

*Crop sown in September and harvested in spring

Table 1: Statistical models used in the study

S #	Model	Mathematical Equation
1	Linear	$Y_t = a + bt$
2	Quadratic	$Y_t = a + bt + ct^2$
3	Exponential	$Y_t = a e^{bt}$
4	S-curve	$Y_t = \text{Exp}(a + b/t)$
5	Double Exponential Smoothing	$L_t = \alpha Y_t + (1 - \alpha) [L_{t-1} + T_{t-1}]$
6	ARIMA	$Z_t = \emptyset_1 Z_{t-1} + \dots + \emptyset_p Z_{t-p} + U_t$

2.1. Accuracy measures

In order to assess the appropriate model for forecasting wheat production the accuracy measures also termed as forecasting errors were calculated from all of the trend models. They included Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD) and Mean Squared Deviation (MSD). The model selection was based on the minimum values of these accuracy measures.

3. RESULTS AND DISCUSSION

The trends of wheat production showed an upward trend till year 1976-77 and then it fell down in 1977-78 (see Figure 1). An improvement in wheat production was found in 1978-79 with continued rise till 1982-83. In 1983-84 wheat production dropped, 10881.9 thousand tonnes but it again jumped higher and continued till 2016-17. These fluctuations might be the reason of change in the use of agricultural inputs, area of crop, some natural variations due to increase or decrease in the occurrence of rainfall and the variations in the minimum and maximum temperature.

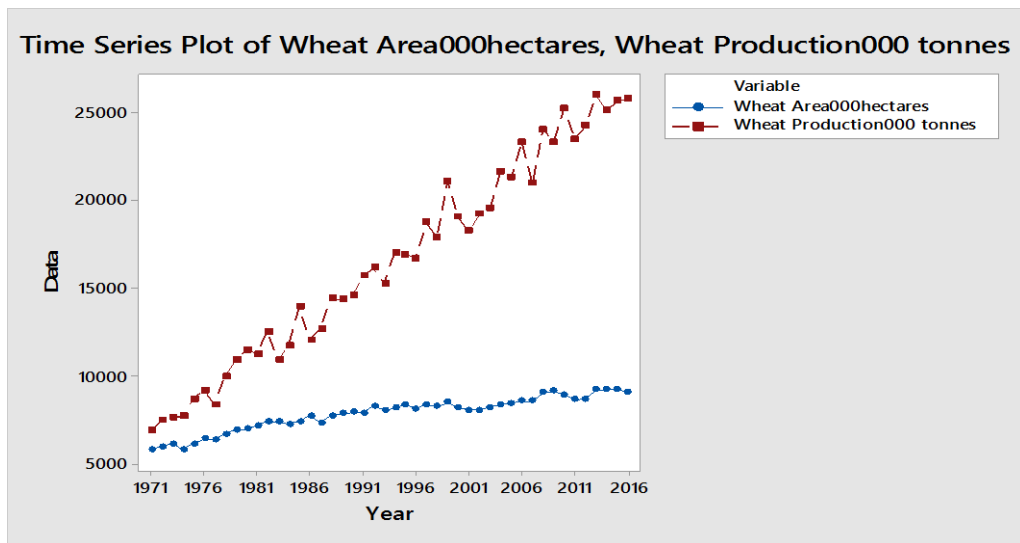


Figure 1: Depicting trend of wheat area and production from 1971 to 2016

In Table 1 it can be seen that values of MAPE, MAD and MSD are minimum (4,666 and 683,407 respectively) for quadratic model. Literature show studies about forecasting wheat area and production nationally and internationally. Some of them include [Najeeb et al. \(2005\)](#) who made forecast about wheat area and production in Pakistan for 2022. In another paper by [Sabir and Tahir \(2012\)](#) an attempt has been made to forecast wheat production by using exponential

smoothing. Similarly regression and trend analysis techniques have been employed by [Karim et al. \(2005\)](#) to forecast wheat production in Bangladesh.

Table 2: Linear and nonlinear models of wheat production in Pakistan

Fore casting Models	Criteria for model selection		
	MAPE	MAD	MSD
Linear	4	673	690546
Quadratic	4	666	683407
Exponential	7	1024	1658875
S-curve	4	672	704175
Moving Average	7	1066	1759221
Single Exponential Smoothing	6	999	1569105
Double Exponential Smoothing	5	841	1075722

The data was also tested for ARIMA models and the results are given in table 2 and table 3 respectively. Initially plots of auto correlation function (ACF) and partial auto correlation function (PACF) were obtained and they showed non stationary series because auto correlation did not fall within the prescribed 5% significant limits. In order to make the series stationary for production differenced series was obtained by putting the value of ‘p’ equal to 2, the difference or ‘d’ value equal to 1 and finally the order of moving average value ‘q’ was set to be 2. Therefore, ARIMA (2,1,2) was used for estimating production of wheat by using this order. This confirms with the finding of a similar study by [Najeeb et al. \(2005\)](#) to estimate wheat area and production in Pakistan by using ARIMA model.

The forecasts with ARIMA (2,1,2) model are compared over quadratic model to find best one for production of the years 2014-15, 2015-16, 2016-17, 2017-18, 2018-19 and 2019-20, the preference inclines towards the ARIMA model due to close values of Forecasts of wheat production to actual values of wheat production than quadratic model (Table 2). Finally, ARIMA (2, 1,2) was identified best one due to close forecasts estimates with actual reported wheat production. Using ARIMA (2,1,2) 3 years ahead forecasts of wheat production and their 95 % confidence intervals are given in table 3. It is concluded that there is 95 percent probability, forecasts estimates lie between lower and upper limits.

Table 3: Time series models of wheat production in Pakistan

Diagnostics	ARIMA(1,1,1)	ARIMA (0,1,0)	ARIMA (0,1,1)	ARIMA(1,2,1)	ARIMA(2,1,2)	ARIMA(1,2,2)	ARIMA (2,2,2)
R-square	0.97	0.94	0.97	0.96	0.97	0.96	0.96
RMSE	870.66	1326.12	885.85	1131.24	882.28	1081.77	1110.05
MAPE	4.28	6.42	4.38	5.92	4.17	5.65	5.65
MAE	12.26	1046.5	684.15	912.72	649.35	872.97	882.07
MAXAPE	666.21	19.35	12.40	15.34	12.04	15.07	15.50
MAXAE	2183.79	2801.88	2372.93	2671.35	2161.92	2635.35	2384.30
Normalized BIC	13.79	14.46	13.74	14.32	13.95	14.31	14.45

Table 4: Actual and forecast values of wheat production in thousand tones with the best models

Year	Actual	Quadratic	ARIMA	95%limits	
				Lower Limits	Upper limits
2014-15	25086.1	25827.1	24775.6	23083.7	26467.6
2015-16	25633.0	26316.4	26084.8	24362.8	27806.8
2016-17	25750.0	26808.1	25919.2	24197.1	27641.2
2017-18		27302.1	26824.3	25094.5	28554.1
2018-19		27798.5	26857.9	25123.8	28591.9
2019-20		28297.2	27635.8	25893.4	29378.3

4. CONCLUSION AND RECOMMENDATIONS

In this study, various forecasting models were tried to find best one in relation to future wheat production in Pakistan using historical/ large data of forty six (46) years, but ARIMA (2,1,2) was identified as best one to forecast of wheat production for three years ahead. For 2017-18, 2018-19 and 2019-2020 forecasts of wheat production 26824.3, 26857.9 and 27635.8 thousand tones can be with lower and upper limits 25094.5 to 28554.1, 25123.8 to 28591.9 and 25893.4 to 29378.3 respectively. It is suggested that different crops data can be used to fit models and also make forecast using other advanced forecasting models for provinces and districts.

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