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Trend Analysis and Forecasting of Maize Area and Production in Khyber Pakhtunkhwa, Pakistan

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Abstract:

The present study focuses on making forecast of maize area and production in Khyber Pakhtunkhwa province of Pakistan using time series data from 1980-81 to 2011-12 (31 years). Five forecasting models such as Linear trend model, Quadratic trend model, Exponential growth model, Moving Average Model and Double exponential smoothing model were used to find the best fitted model for area and production of maize crop in Khyber Pakhtunkhwa. Forecasting errors namely mean absolute percentage error (MAPE), mean absolute deviation (MAD) and mean squared deviation (MSD) were used as model selection criteria. The study showed that quadratic model was appropriate for predicting future estimates of maize area and production in Khyber Pakhtunkhwa due to lowest values of the

forecasting errors. The forecast values of both area and production depicted decreasing trend. The turn down in the area of maize may be due to the shifting of maize area to other Kharif crops. Making timely forecast of this crop will enable the policy makers and government to take wiser steps for enhancing maize production in Khyber Pakhtunkhwa and as a result increased production of maize will definitely contribute in meeting the demands of this crop at provincial and national level.

Key words: Forecasting, maize, trend analysis, area and production

Introduction

Maize is an important staple food in many countries of the world and the acreage and production of maize in the world have been increasing continuously. Though the acreages have not been so erratic, the production has been a bit volatile mainly due to the variations in the yield. The area under the maize is continuously increasing over the years. If we examine production figures, global maize production reached its high of 885.3 million tons during 2011 (FAO, 2013). The variations in production are mainly due to yield which is affected by a lot of factors. Factors like weather during crop growth, pest and disease attack, technological advances and development of new hybrids and varieties affect the yield of corn (Haradi, S. 2010).

In Pakistan, the bulk (99.8 percent) of the total production is produced by the two provinces, Punjab and Khyber Pakhtunkhwa. During 2011-12 in Pakistan, maize was sown on an area of 974.2 thousands hectares; with a total production of 3707 thousand tones. In Khyber Pakhtunkhwa during the same year total area under maize was 422.9 thousand hectares (43.41 % share in the country) with a total production of 740.5 thousand tones (19.98 % share in the country) (Table-1).

Table-1: Area and production of maize and their Shares in Pakistan, 2011-12

Provinces	Area (000 hectares)	% Share in Total Area	Production (000 tones)	% Share in Total Production
Punjab	543.6	55.80	2959.2	79.83
Khyber Pakhtunkhwa	422.9	43.41	740.5	19.98
Sindh	2.5	0.26	1.6	0.04
Baluchistan	5.2	0.53	5.7	0.15
Pakistan	974.2	100.00	3707	100.00

Source: GoKP, 2013

Government needs accurate and advance information about the status of all major crops such as wheat, rice maize etc ahead of harvest and till the availability of final estimates. Therefore, accurate forecasting of maize area and production may support the policy makers and planners for making policy decision regarding supply, demand and import of maize in the province. Many researchers have accomplished substantial of work on forecasting of area and yield of wheat and rice crop but very marginal work has been done on maize forecasting. A number of forecasting models for projecting the crop have been formulated earlier. A few of them are by Azhar et al (1973), Amir & Akhtar (1984), Falak Sher & Eatzaz Ahmad (2008) for wheat crop and Khan and Khan (1988), Maria and Tahir (2011) for rice crop, Niaz et al (2013) for lentil pulses, Asif and Anver (2004) for sugarcane crop, Badmus and Ariyo (2011) and Tahir and Habib (2013) for maize crop.

Keeping in view the importance of maize crop there is a need to forecast cultivation area and production of maize in Khyber Pakhtunkhwa. The main objective of this paper is therefore, to develop forecasting models for maize area and production in Khyber Pakhtunkhwa using past trends and based on the above forecasts, predict area and production of maize in the Khyber Pakhtunkhwa.

Methodology

The present study was conducted using time series data of maize area and production in Khyber Pakhtunkhwa province of Pakistan from 1980-81 to 2011-12 (31 years). The secondary data were collected from various issues of Crops Statistics of Khyber Pakhtunkhwa. Data was analyzed in Statistical software Minitab Version 16.

Analytic Techniques

Five forecasting models such as Linear trend model, Quadratic trend model, Exponential growth model, Moving Average Model and Double exponential smoothing model were used to find the best fitted model for area and production of maize in Khyber Pakhtunkhwa. The general forms of these models as given in the (Minitab software 2013) are described below:

Forecasting Models

1. **Linear Trend Model:** $Y = b_0 + b_1 t$
2. **Quadratic Trend Model:** $Y = b_0 + b_1 t + b_2 t^2$
3. **Exponential Growth Model:** $Y = b_0 e^{b1t}$

where

Y = area and production of maize in KP;

t = Trend which determines the tendency of time series data to increase or decrease over time and b_0 and b_1 are the parameters of the model.

4. **Moving Average Model** $Y = \mu + \varepsilon_t + \alpha_1 \varepsilon_{t-1} + \ldots\ldots + \alpha_q \varepsilon_{t-q}$

where

μ is the mean of the series, the α_1, ..., α_q are the parameters of the model and the ε_t, ε_{t-1},...

are white noise error terms. The value of q is called the order of the moving average model.

5. Double Exponential Smoothing Model

The algebraic form of the linear exponential smoothing model can be expressed as follows:

S' denotes the singly smoothed series obtained by applying simple exponential smoothing to series Y. That is, the value of S' at period t is given by:

$$S'(t) = \alpha Y(t) + (1-\alpha)S'(t-1)$$

Let S" denote the doubly smoothed series obtained by applying simple exponential smoothing

$$S''(t) = \alpha S'(t) + (1-\alpha)S''(t-1)$$

Finally, the forecast Ý(t+1) is given by:

$$Ý(t+1) = a(t) + b(t)$$

where: $a(t) = 2S'(t) - S''(t)$ the estimated level at period t.

$b(t) = (a/(1-\alpha))(S'(t) - S''(t))$ the estimated trend at period t

Diagnostic Measures for the Selection of Best Forecasting Model

Reliability of the forecasting methods was based on three accuracy measures also termed as forecasting errors. These measures include Mean Absolute Percentage error (MAPE), Mean Absolute Deviation (MAD) and Mean Squared Deviation (MSD). Mean Absolute Percentage Error (MAPE) measures the accuracy of fitted time series values. It expresses accuracy as a percentage. Mean Absolute Deviation (MAD) measures the accuracy of fitted time series values. It expresses accuracy in the same units as the data, which helps conceptualize the amount of error. Mean Squared Deviation (MSD) is always computed using the same denominator, regardless of the model. MSD is a more sensitive measure of an unusually large forecast error than MAD. Smaller values of all these measures indicate a good fitted Model with minimum forecasting errors (Karim et al., 2010). The best fitted Model for this study was Quadratic Model; and the stationary series of the data was used in the

model identification. This Model was also applied by Finger (2007) and applied for forecasting the area and production of Maize in Pakistan for the years 2012 to 2017 respectively.

Trend and rate of growth in Maize crop of Khyber Pakhtunkhwa

Maize (*Zea mays* L.) is an exhaustive cereal crop. It is a multipurpose crop that provides food for human, feed for animals especially poultry and livestock and raw material for the industries (Khaliq *et al*., 2004). Maize is the second most important crop after wheat in the Khyber Pakhtunkhwa, and for much of the province, it is the dominant crop in the farming system (Byerlee and Sajidin, 1986). Table-3 indicates that maize was planted in Khyber Pakhtunkhwa in 1981-85 on an area of 420.4 thousand hectares with production of 534.2 thousand tones and yield 1272 kgs per hectare. In the year 2010-12 the maize area, production and yield was increased to 449.1 thousand hectares with an annual production of 814.2 thousand tones and yield 1809 kgs per hectare.

Table-3: Trend in area, production and yield of maize crop in KP, 1981-2012 (5-Yrs Avg)

Years	Area '000' hectares	Production '000' tones	Yield (kgs per hectare)
1981-85	420.4	534.2	1272
1986-90	473.8	675.8	1424
1991-95	519.8	781.2	1503
1996-00	534.0	820.0	1536
2001-05	517.6	875.0	1691
2006-10	489.7	863.0	1762
2010-12*	449.1	814.2	1809

Source: Various issues of Crops Statistics Khyber Pakhtunkhwa *2-Yrs Average

Diagnostic Measures for the Selection of Best Fitted Model:

To find the best fitted model for area and production of maize crop in Khyber Pakhtunkhwa different forecasting models such as Linear trend model, Quadratic trend model, Exponential growth model, Moving Average Model and Double exponential smoothing model were used. The Quadratic trend Model was best fitted for trend analysis of Maize area and production in Khyber Pakhtunkhwa on the basis of smaller values of accuracy measures (Karim et al., 2010), Ayesha Tahir, Nusrat Habib (2013). The Quadratic Model shows the small values of all accuracy measures like MAPE, MAD, MSD, so therefore this model is best fitted model and is being selected as a best model for forecasting. The diagnostic measures for the selection of best forecasting model for maize area and production in Khyber Pakhtunkhwa were summarized in Table-1 &2. It was revealed from the results that the value of forecasting errors were lowest for quadratic model and was consequently selected as a best fitting model for predicting maize area in Khyber Pakhtunkhwa. The area of maize is declining and that is apparent from (figure 1). Similarly the Quadratic model was also best fitted for maize production in Khyber Pakhtunkhwa as the value of forecasting errors were lowest so selected as a best fitting model for predicting maize production in Khyber Pakhtunkhwa. The same model was used by Tahir and Habib (2013) to forecast the area and production of maize crop in Pakistan. Results showed that Quadratic trend model was fit well to data. Some studies have been conducted for predicting future estimates of major and minor crops in Pakistan using the same model selection criteria. For instance Rani and Raza (2012) made use of trend analysis and double exponential smoothing method for price estimation of major pulses in Pakistan. Ayesha Tahir, Nusrat Habib (2013) used trend

analysis technique to forecast maize area and production in Pakistan. Results showed that Quadratic trend model was fit well to data.

Table-1: Diagnostic measures for the selection of best fitted model for maize area in KP

Forecasting models	Criteria		
	MAPE	**MAD**	**MSD**
Linear trend model	7.13	33.58	1650.69
Quadratic trend model	**2.65**	**12.46**	**275.07**
Exponential growth model	7.20	34.03	1676.37
Moving Average Model	3.58	16.75	688.16
Double exponential smoothing model	3.541	16.64	464.02

Author's own calculation

Table-2: Diagnostic measures for the selection of best fitted model for maize production in Khyber Pakhtunkhwa

Forecasting models	Criteria		
	MAPE	**MAD**	**MSD**
Linear trend model	8.11	58.30	4923.66
Quadratic trend model	**4.39**	**33.69**	**1938.74**
Exponential growth model	8.70	63.24	5844.46
Moving Average model	6.34	49.40	4258.68
Double exponential smoothing model	5.78	44.16	3029.83

Author's own calculation

Figure-1: Trend analysis plot for maize area in Khyber Pakhtunkhwa

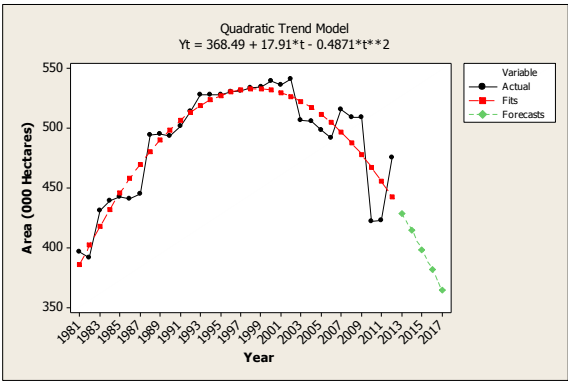
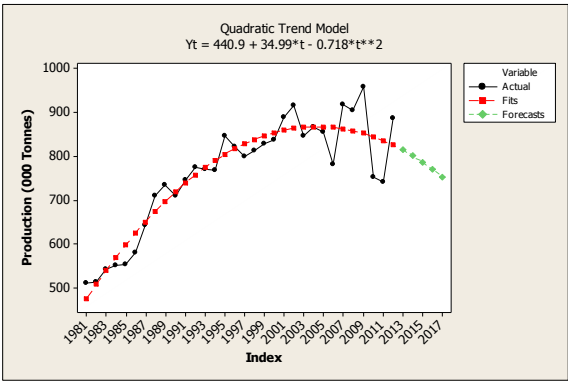


Figure-2: Trend analysis plot for maize production in Khyber Pakhtunkhwa



Five years forecast values of maize area and production in Khyber Pakhtunkhwa were presented Table-3. The forecast values of maize area were 428.9, 414.3, 398.6, 381.9 and 364.2 thousand hectares and production 814.1, 801.0, 786.5, 770.5, 753.1 thousand tones for the year 2012-13 to 2016-17 respectively. The results indicated that the area under maize crop is declining gradually till 2016-17. It may be due to the shifting of maize area to other Kharif crops in the province. The production of maize is also decreasing due the corresponding decrease of maize area in Khyber Pakhtunkhwa. The same results were found by Tahir and Habib (2013) to forecast the area and production of maize crop in Pakistan. Results showed that Quadratic trend model was fit well to the maize data of Khyber Pakhtunkhwa.

Table-3: Five years forecast of area and production of maize crop in Khyber Pakhtunkhwa

Years	Area ('000' hectares)	Production ('000' tones)
2012-13	429.0	814.1
2013-14	414.3	801.0
2014-15	398.6	786.5
2015-16	381.9	770.5
2016-17	364.2	753.1

Source: Author's own calculation

Conclusions and Recommendation

The study showed that quadratic model was appropriate for predicting future estimates of maize area and production in Khyber Pakhtunkhwa due to lowest values of the forecasting errors. The forecast values of both area and production depicted decreasing trend. The turn down in the area of maize may be due to the shifting of maize area to other Kharif crops. The production of maize is also decreasing due the corresponding decrease of maize area in Khyber Pakhtunkhwa. Making timely forecast of this crop will enable the policy makers and government to take wiser steps for enhancing maize production in Khyber Pakhtunkhwa and as a result increased production of maize will definitely contribute in meeting the demands of this crop at provincial and national level.

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