A Study on Estimation of Trends in Area and Production of Food Grains in Himachal Pradesh

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Abstract— The present study deals with the estimation of trends in area and production of food grains in Himachal Pradesh was carried out using secondary time series data on area and productivity of food grains for last 26 years from 1989 to 2014. Different prediction models viz. linear, quadratic, compound power and autoregressive model were tried to forecast the area and production of food grains. Significant$(\overline{R})^2$, lowest SE, were selection criteria for a model. Power model was best fitted model to predict the food grains production on the basis of area in Himachal Pradesh. An increase in productivity in food grains was detected during the studied period.

Keywords: Linear, Quadratic, power, compound, SE

I. Introduction

Since long agriculture remains the main occupation of the people of Himachal Pradesh. It provides direct employment to about 71% of the total working population. Agriculture is beset with the disadvantage of small holdings. Only 65% of the total reported area is available for cultivation. Out of this area, net area sown and current fallows account for only 21% (Economics and Statistics Department Himachal Pradesh). There is barely any possibility of mechanized and technologically sound farming due to predominance of small holdings, scanty irrigation and terraced fields. Despite all these difficulties, the farmers of Himachal Pradesh are persistently trying to exploit the agricultural potential of the state to increase food production and also to supplement the income by producing commercial crops. The economy of Himachal Pradesh has shown a shift from agriculture sector to industries and services as the percentage contribution of agriculture and allied activities in State Domestic Product has decreased from 58% in 1950-51 to 23% in 2004-05. The declining share of agriculture sector, however, did not affect the importance of this sector in the state economy. The growth of the economy has fundamentally been determined by the trend of agricultural production as it has considerable share in the State Domestic Product and has overall impact on other sectors via input linkages, employment and income. Due to lack of irrigation facilities, agricultural production largely depends upon timely rainfall and weather conditions of the state. Within agriculture, food grains production is by far the major activity and providing the main staple source of food in the state. Food grains provide almost all the calories and proteins consumed by the poor and give the rural people with the bulk of their employment. So the growth of agriculture sector depends on production and productivity of food grains. Oberoi and Raina found that among the food grains paddy, maize and wheat play a dominant role and occupy as much as 85% of the total area under cultivation. A study by Kumar et al revealed that area under food grains has contracted during nineties. Therefore, keeping in view theimportance of food grains in the agrarian economy of the state, it is desirable to analyze whether there has been any considerable change in the area, production and productivity of food grains or not. Former President of India also called upon the agriculture scientists to enable Himachal Pradesh farmers to achieve self-sufficiency in food grains production during his visit to Chaudhary Sarvan Kumar Himachal Pradesh Agricultural University, Palampur. Oberoi and Raina concluded that area under total food grains in Himachal Pradesh had increased at the rate of 0.5219 % per annum. Their study had covered the period 1975-76 to 1986-87. According to them the area under wheat and maize was increased whereas area under paddy and pulses decreased significantly over the study period. However there had been significantly decline in case of pulses. The instability was found to be highest in the production of pulses. Moorti et alexamined the trends in the production of pulses and oil seeds in Himachal Pradesh. According to them area, production and productivity of all pulses show significant negative trends of 3.69, 10.31 and 6.87 per cent per annum respectively over the study period (1970-71 to 1987-88). There has been marginal non- significant increase in the area under other pulses which included lentil, green gram, red gram and beans etc. Mitra and Jena studied the area, production and yield per hectare of groundnut crop. They calculated compound growth rates in relation to area, yield and production. They found in their study that only extension of the area under groundnut cultivation will not solve the problem of increasing the production but adequate attention has to be paid to increase the productivity of the crop.

Bhatnagar investigated the trends and pattern of growth in area, production and yield of sunflower in Haryana. He used secondary data of 11 years 1991-92 to 2001-02 and analysed the time series data with the help of linear function. He found that area and production of sunflower in Haryana had been reduced. According to his study area of sunflower has wide variation of 62.29%, whereas the area of oilseed in Haryana has a very slow variation of 14.27%. Similarly, the production of sunflower has a shown a variation of 64.52% and on the other hand oil seed production has a variation of 21.01%. He concluded that the variation in yield has been obtained 12.95% and 17.65% for sunflower and oilseed respectively in Haryana. Sunflower has maximum variability in the area and production. Kumar et al studied growth trends of area and production of pigeon pea in India. They utilized the time series data (1949-50 to 2001-02) on area, production and yield of pigeon pea. The growth trends of area and production were expressed by the functional form y=a+bt. According to study the growth in pigeon pea both in area and production has shown increasing trend in the country. Their study also shows that the best trend in area and production is quadratic in nature. The significantly positive square turn in the quadratic equation indicates acceleration in pigeon pea area and production in the country during the study period. Kumar et al examined the time series data for lentil (1970-71 to 2006-07) to assess production status, growth patterns and growth trends of area and yield along with their interaction. During overall period, the country has shown growth in area

(0.934%) and production (3.32%). The results reveal that co-efficient for area in the country varies from 7% to 13%. During the study period, the change in the total production of lentil was completely due to the change in area under the crop as the yield and interaction effects were very small. Kumar et al made a case study of district Solan of Himachal Pradesh regarding land use and cropping pattern. In their findings they revealed that, there were some important variations under area in case of permanent pasture and net sown area. Other land categories had not shown significant change under their area. The study on the cropping pattern in district over the study period suggest that among food crops area under wheat and paddy had increased whereas, in case of barley and maize it had declined considerably. Area under nonfood crops had shown increased trend for cash crops. They also observed that total cropped, net sown area, and area sown more than once decreased over the study period. The present study is intended to examine the variation rates of area, production and productivity of different food grains and to estimate the instable production rate

II. MATERIAL AND METHODS

The study belongs to the state of Himachal Pradesh. Food grains were included in the study. Time series data on area and production of food grains from 1989 to 2014 (26 years) were used for statistical investigation. The secondary data were taken from Directorate of Agriculture Shimla (Anonymous 2018b)

A. Regression Analysis:

Regression analysis was performed with linear, quadratic, cubic and compound models. Autoregressive models of first, second and third orders were also used to study the trend in the data. By considering the time as an independent variable, various linear and nonlinear regression models were used for prediction of area and production of food grains.

1) Linear Model: $Y_t = a + bt + e_t$
2) Quadratic Model: $Y_t = a + bt + ct^2 + e_t$
3) Cubic Model: $Y_t = a + bt + ct^2 + dt^3 + e_t$
4) Compound Model: $Y_t = ab^t + e_t$
   where,
5) Y_t = time series values of dependent variable.(Area and Production)
6) t = time period
7) a = intercept
8) b, c and d = regression coefficients
9) e_t = error term

B. Model Adequacy:

Model adequacy investigates the fit of regression model to the available data. It includes residual analysis, R^2, $\overline{R^2}$ etc. Standard error and t- statistic were computed to test the significance of parameters of the regression models used in the study. Adjusted coefficient of multiple determination $\overline{R}^2$, root mean square error and Thiel's inequality coefficient had been used to check the adequacy of the fitted models.

C. Root Mean Square Error (RMSE):

The root mean square error is a frequently used measure of the differences between values predicted by a fitted model and the actual values. The RMSE represents the standard deviation of the differences between predicted values and actual values. This statistic is also known as fit standard error and standard error of regression. It is an estimate of the standard deviation of error component of the data.

$$RMSE = \sqrt{MSE} = \sqrt{\frac{\sum_{t=1}^{n}(Y_t - \hat{Y}_t)^2}{n-k}}$$

where,
MSE = Mean Sum of Squares due to Error
Y_t = actual value of the response variable
$\hat{Y}_t$ = estimated value of the fitted model

D. Coefficient of multiple determination:

It is the square of the correlation coefficient and it judges the explanatory power of the regression model. R^2 is the percentage of total variation in the dependent variable that can be explained by the independent variables,

$$R^2 = \frac{RSS}{TSS} = 1 - \frac{ESS}{TSS}$$

where,
RSS = Regression Sum of Squares
TSS = Total Sum of Squares
ESS = Error Sum of Square

E. Adjusted coefficient of multiple determination:

In case of more than one regressor variables, R^2 sometimes misleads results regarding the fitting of model. So, instead of using R^2 we use $\overline{R}^2$.

$$\bar{R}^2 = 1 - \frac{\frac{ESS}{(n-k-1)}}{\frac{TSS}{(n-1)}} = 1 - \frac{(1-R^2)(n-1)}{(n-k)}$$

where,
ESS = Error Sum of Square
N = number of observations
K = number of variables

F. SE = Standard Error:

Standard error of the regression coefficients is useful in testing the significance of regression coefficients.

If the estimate of regression coefficient is non-significant then the regressor to which this estimate of regression coefficient relates does not in fact influence the response (dependent variable).

III. RESULTS

Models	R	R^2	Adj R^2	Standard Error
Linear	0.993	0.987	0.986	163232
Logarithm	0.994	0.988	0.988	152.770
Inverse	0.994	0.988	0.987	155.940
Quadratic	0.994	0.988	0.987	155.040
Cubic	0.994	0.988	0.987	155.040
Compound	0.999	0.998	0.998	0.287
Power	1	1	1	.123
Sigmoid	0.999	0.999	0.999	0.227
Growth	0.999	0.998	0.998	0.287
Exponential	0.999	0.998	0.998	0.287

Power model was the best fitted model to predict the area and production of food grains in Himachal Pradesh as it contains minimum standard error value of 0.123 and maximum value of adjustedR^2.

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