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Short Communication

Rice yield prediction in lower Gangetic Plain of India through multivariate approach and multiple regression analysis

RIA BISWAS* and B. BHATTACHARYYA

Department of Agricultural Statistics, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia 741 252, West Bengal, India.

**Corresponding Author: E-mail: ria.biswas6@gmail.com*

Forecasts of crop yields can provide very crucial information about product markets and are frequently used by farmers, industry and government for decisions making. Farmers may use forecasts to plan their harvest, storage and distribution strategies in advance. For maximum crop production interaction between the meteorological factors and agricultural set-up is prime requisite. It is necessary to study such effects to find out the crop yield considering the critical stages of crop life. Various research approaches are available for statistical forecast based on meteorological data (Agrawal *et al.,* 1986).Individual effects of weather factors on crop yield forecast have been studied from nineteenth century (Jain *et.al.,* 1980). However, the combined effects of weather factors influence the crop yield more precisely (Hendricks and Scholl 1943; Runge 1958).Discriminant function analysis is also an useful tool to determine crop yield (Sisodia *et al.,* 2014) and odell.

In this paper an attempt has been made to compare the forested yield at district level using two different statistical models developed by discriminant function analysis of weekly data on weather variables and composite effects of maximum temperature, rainfall and relative humidity with their interaction terms. The study was conducted for Nadia District, West Bengal, India, which falls under New Alluvial Agro-climatic Zone. The district level Aman rice yield data were collected from District Statistical Handbook (Nadia), published by the Bureau of Applied Economics and Statistics, Government of West Bengal for the period of 1990-2013.Meteorological data on weekly rainfall, mean relative humidity and mean temperature for 16 weeks (23^{rd} to 36^{th}SMW) were collected from regional meteorological station, Alipore for the above said period. Last three years (2011-2013) data sets were utilized for model validation.

Discriminant function analysis

Discriminant function analysis was carried out on three different weather indices following Sisodia *et al.,* 2014) and two discriminant scores were obtained for each year. To develop forecast model through regression technique these two discriminant scores and time trend were utilized (Biswas and Bhattacharyya, 2016).

The form of model considered is as follows

$$Y= \alpha + \beta_1 ds_1 + \beta_2 ds_2 + \beta_3 T + \varepsilon$$

where, Y is the crop Yield, ± is the intercept of the model, β_{lm}'s (l=1,2,3; m= 1,2,…, 4) and β_t are the regression coefficient, ds_{lm} is the i^{th} discriminant scores in m^{th}phase, T= the trend variable (year) and ε = error~ N(0,σ^2)

This model utilizes the complete data over all 16 weeks and also considers relative importance of weather variables in different weeks.

Multiple linear regression (MLR) models using generated weather indices

The present methodology attempted to eliminate trend effect by introducing detrend production index (DPI).For estimating the detrended production the actual Aman rice yield data (P) in each year during the study period (1990-2013) was expressed as a percentage of the corresponding trend value (T) to obtain the de trended production index as follows:

$$DPI = \frac{P}{T} * 100$$

The DPIs are expected to be free from the technological trend and their year to year variations. It included the multiple effects of three weather variables at a time. The model is further modified as follows:

$$DPI = A_0 + \sum_{i=1}^{3}\sum_{j=0}^{2} a_{ij} z_{ij} + \sum_{i \neq i'=1}^{3}\sum_{j=0}^{2} a_{ii'j} Q_{ii'j} + \sum_{i \neq i' \neq i''}^{3}\sum_{j=0}^{2} a_{ii'i''j} R_{ii'i''j}$$

where, DPI is the detrend production index, A_o, a_{ij}, $a_{ii'j}$, $a_{ii'i''j}$ (i = 1,2,,3; j =0, 1, 2) are unknown

Table1: Comparison between output of Discriminant Function Analysis model (DFAM) and detrended production index model (DPIM)

Year	Observed DPI (O)	Forecasted DPI through DFAM (FD)	Forecasted DPI through DPIM (FP)	Accuracy % FD	FP
2011	98.52	98.91	95.26	99.60	103.43
2012	73.15	103.21	105.80	70.87	69.14
2013	84.11	103.94	87.70	80.92	95.91
Mean	85.26	102.02	100.53	83.80	89.49
Bias		16.76	10.99		
MAE		16.76	13.17		
MSE		432.36	363.19		
RMSE		20.79	19.06		

constants and parameters of regression model. Z, Q and R are the first, second and third order generated weather variables (Biswas and Bhattacharyya, 2017).

The developed model can be utilized to forecast Aman rice yield by regression analysis. Fitted DPI values were originated from the correlation of DPI and generated weather parameters. The accuracy percentage of the model can be obtained from the DPI and fitted DPI values(Bhattacharyya and Bhowmik, 2012). Three years (2011 to 2013) data were used for validation of the models. Some common statistical parameters, namely, bias, mean absolute error (MAE), mean square error (MSE), root mean square error (RMSE), etc., were worked out to evaluate the performance of the model (Fox, 1981).

The forecast models, developed through multiple regression followed by discriminant function analysis used to forecast Aman rice yield.

$$\text{Yield (DPI)} = 101.225 + 2.538 ds_1 + 5.073 ds_2 - 0.097T \quad \text{—(1)}$$

(0.029) (0.378) (0.137) (0.064)

$$DPI = 48.741 + 0.129 Z_{10} + 0.414 Z_{21} - 9.052 Z_{31} + 7.849 Z_{32} - 0.004 Q_{231}$$

(13.978) (0.072) (0.312) (0.018) (0.287) (0.002)

$$- 0.026\, Q_{232} - 0.025\, Q_{312} + 0.001\, R_{1231} \quad \text{—(2)}$$

(0.012) (0.015) (0.004)

From the analysis of the multiple regression (step down process) equation with composite effects of rainfall, relative humidity and temperature on DPI's was obtained with $R^2 = 0.814$. The per cent variations in both the models were significant at 5 per cent level of significance.

The detrended yield data of 2011-2013 were utilized to predict the yield. Table 1 shows the variation of actual and predicted detrended yield both the models. From Table 1 it is observed that the detrended production index (DPI) model performs better than discriminant function analysis model.The mean absolute error value, MSE value, RMSE value for detrended production index model is lesser than discriminant function analysis model values. The accuracy per cent of detrended production index model is higher than Discriminant Function Analysis model which indicating the detrended production index model can predict the yield in a better way for this region.Hence, for region-specific yield prediction, detrended production index model can be used as an alternative one.

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