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Forecasting Of Potato Production In Selected Districts Of Karnataka State

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Abstract: An attempt has been made in this study to analyze the forecasting performance of production of potato in selected districts of Karnataka. For the present study the secondary data 24 years dated from 19998-99 to 2021-22, on production of potato for Hassan and Chikkamagaluru districts of Karnataka was collected from the official website of Directorate of Economics and Statistics (DES 2020), Department of Agriculture, Government of Karnataka. The data were analyzed through Exponential Smoothing methods for both the districts, the most suitable method was selected based on minimum Root Mean Square Error (RMSE) and Mean Average Percentage Error (MAPE) values. Study showed that Browns's method outperformed well in both the districts hence, it is used for the forecasting of potato production in Hassan and Chikkamagaluru districts of Karnataka for the next five years i.e. 2022-23 to 2026-27. Hassan district experience decreasing production whereas Chikkamagluru district shows increasing production over the period of time.

Index Terms – Forecasting, MAPE, RMSE, Production, Potato.

I. INTRODUCTION

Vegetables are an essential component of any vegetarian meal, as most people on the planet follow a vegetarian diet. India's diverse environment makes a wide variety of fresh veggies easily accessible throughout the nation. Among the main vegetables grown in India are tomato, onion, brinjal, cabbage, cauliflower, okra, and peas. With an output of 204.84 million metric tonnes from 11.34 million hectares of land area in the year 2021–2022, it trails China in terms of global vegetable production.

After cereals, potatoes (*Solanum tuberosum*), also referred to as "The King of Vegetables," are the basic diet for the many of the Indians. India holds the second highest producer of potato after China in the world. It contributes 26.53 per cent to the total vegetable production and occupying 21.24 per cent to the total area of vegetables in India. Being a major vegetable, it has the huge importance to the processing industry as well. Many processed products of potato such as french fries, potato chips, and potato flakes etc. are available in market. It is a crop with a short growing season that generates more edible protein, edible energy, and dry matter, more quickly than cereals. Thus, it is among the most crucial vegetables for nutrition and food security. Potato protein is higher in biological value than that of grains and is considered to be superior than milk hence, potatoes reduce energy intake and food costs, they are a good complement to meat and dairy products.

Approximate 1/3rd of the world's potato production comes from China and India, making it the world's largest producer of potatoes. More than 80 per cent of the total production came from Gujarat, West Bengal, Punjab, Uttar Pradesh, and Bihar. In India total area under potato is 2.23 million hectares and production are 53.39 million tonnes.

One of the major states in peninsular India that grows potatoes is Karnataka. In six districts of Karnataka, potatoes are one of the major crops. Bengaluru, Belagavi, Chikkamagaluru, Dharwad, Hassan, and Kolar districts are the primary locations of potatoes cultivated. In the districts of Belagavi, Chikkamagaluru,

Dharwad, and Hassan, it is mostly planted as a kharif crop, in Kolar and Bangalore it is cultivated as a rabi crop. While the kharif crop is rainfed whereas the rabi crop is totally irrigated.

In Karnataka total area under potato is 0.026 million hectares and production are 0.37 million tonnes. Production of potato observed during 2021-22 highest in Chikkamagaluru (92,659 tonnes) followed by Hassan (84,210 tonnes) and 76,051 tonnes in Kolar district (DES 2020, Department of Agriculture, Government of Karnataka).

Over the past ten years, the state has seen a little rise in area, production, and productivity. By selling consumable potatoes rather than seed potatoes, traders are also profitable. The number of value-added products is growing daily as new businesses join this market. The study will be helpful in evaluating the state's potato processing industry's growth and potential as well as its area, production and productivity. The study's findings will be beneficial to input agencies, farmers, and policy makers.

Most of the previous studies relating to the performance of agriculture in Karnataka have been made at the aggregate level. This study will provide the information regarding the forecasting performance with respect to production of potato in Hassan and Chikkamagaluru districts of Karnataka. A district-level detailed study would be extremely beneficial to policy makers to formulate relevant and appropriate agricultural policies and programs for all the districts.

Keeping this in reference, the study was undertaken with the following objective,

- To forecast the production of potato in Hassan and Chikkamagaluru districts of Karnataka.

II. METHODOLOGY

Study area:

The Karnataka state was delineated into 31 district and 176 taluks spread over 27,481 villages. The selection of the district for the research study is purely based on the existing ranking performance among the districts existing in Karnataka state based on the production of potato over a specified period. This study was carried for the Hassan and Chikkamagaluru district of Karnataka state, for analysing the forecasting performance with respect to production of potato crop for the next five years i.e. 2022-23 to 2026-27.

2.1 Research Data:

The secondary data pertaining to production of potato in Hassan and Chikkamagaluru districts of Karnataka for the period of 24 years i.e., from 1998-99 to 2021-22 collected from the official website of the Directorate of Economics and Statistics, Department of Agriculture, Government of Karnataka.

2.2 Analytical Tools and Techniques:

Exponential smoothing methods are employed for the forecasting of potato production in Hassan and Chikkamagaluru districts of Karnataka. The best method was selected based on minimum MAPE and RMSE values, also satisfied the autocorrelation assumption.

2.2.1 Holt's Two-Parameter Linear Exponential Smoothing Method

The forecast for Holt's linear exponential smoothing is found using two smoothing constants, α and β (with values between 0 and 1), and three equations (Holt 2000).

$$\textbf{Level: } L_t = \alpha Y_t + (1 - \alpha)(L_{t-1} + b_{t-1}) \quad \ldots (1)$$

$$\textbf{Trend: } b_t = \beta (L_t - L_{t-1}) + (1 - \beta) b_{t-1} \quad \ldots (2)$$

$$\textbf{Forecast: } F_{t+m} = L_t + m\, b_t \quad \ldots (3)$$

2.2.2 Brown's One-Parameter Linear Exponential Smoothing Method

Its smoothing parameters are level and trend, which are not constrained by each other's values. It is suitable method or time series that $y_1, y_2 \ldots, y_n$ has insignificant trend.

$$y_t' = \alpha\, y_{t-1} + 1 - \alpha\, y_{t-1}' \quad \ldots (4)$$

$$y_t' = y_{t-1} + \alpha\,(y_{t-1} - y_{t-1}') \quad \ldots (5)$$

$$y_t' = y_{t-1} + \alpha\, e_t \quad \ldots (6)$$

Where, y_t' = estimation value for the time t.

y_{t-1}' = estimation value for the time t-1.

y_{t-1} = observation data for the time t-1.

2.2.3 Damped Two-Parameter Linear Exponential Smoothing Method

The damped trend method can be written in several different forms (Hyndman et al., 2008). The original recurrence form (Gardner and McKenzie, 1985)

Level: $L_t = \alpha Y_t + (1 - \alpha)(L_{t-1} + \varphi\, b_{t-1})$ … (7)

Trend: $b_t = \beta (L_t - L_{t-1}) + (1 - \beta)\, \varphi b_{t-1}$ … (8)

Forecast: $F_{t+m} = L_t + m\, b_t \sum_{i=1}^{h} \varphi^i$ … (9)

If $0 < \varphi < 1$, the trend is damped, if $\varphi = 1$, the equations become identical to the Holt's Linear Trend method.

The predictive accuracy of the methods applied for the study was measured by Mean Average Percentage Error (MAPE), Bayesian Information Criterion (BIC) and Root Mean Square Error (RMSE) values. MAPE was selected to be the main measure of the evaluation, as it is widely used in cases of combining and selecting forecasts in a forecasting model.

Adequacy measures:

a) Root Mean Square Error (RMSE):

$$RMSE=\sqrt{\frac{\sum_{i=1}^{n}(Y_t-\widehat{Y_t})^2}{n}} \text{ ……..(10)}$$

Where, Y_t= Observed value, $\widehat{Y_t}$= Predicted value and n= Number of observations.

b) Mean Average Percentage Error (MAPE):

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{Y_i-\hat{Y}_i}{Y_i}\right| X\ 100 \text{……(11)}$$

Where, Y_i= Actual values, $\hat{Y}_i$= Predicted values and n= Number of observations.

c) Bayesian Information Criterion (BIC):

The formula for BIC is

$$BIC = K \ln(n) - 2\ln(L(\theta)) \text{ …….. (12)}$$

Where, n = Sample size, K = Number of independent variables, θ = Set of all the parameters and $L(\theta)$ = Loglikelihood estimate for θ.

III. RESULTS AND DISCUSSION.

4.1 Forecasting performance of potato production in Hassan and district.

Study shows that only the parameters of Brown's method was found to be significant at the given level of significance, whereas the Holt's linear and Damped trend method parameters were determined to be non-significant. The L Jung Box Q test statistic for all exponential smoothing methods found to be non-significant (p-value>0.05) at the 5 per cent level of significance, suggesting that autocorrelation assumption is met (Table 1).

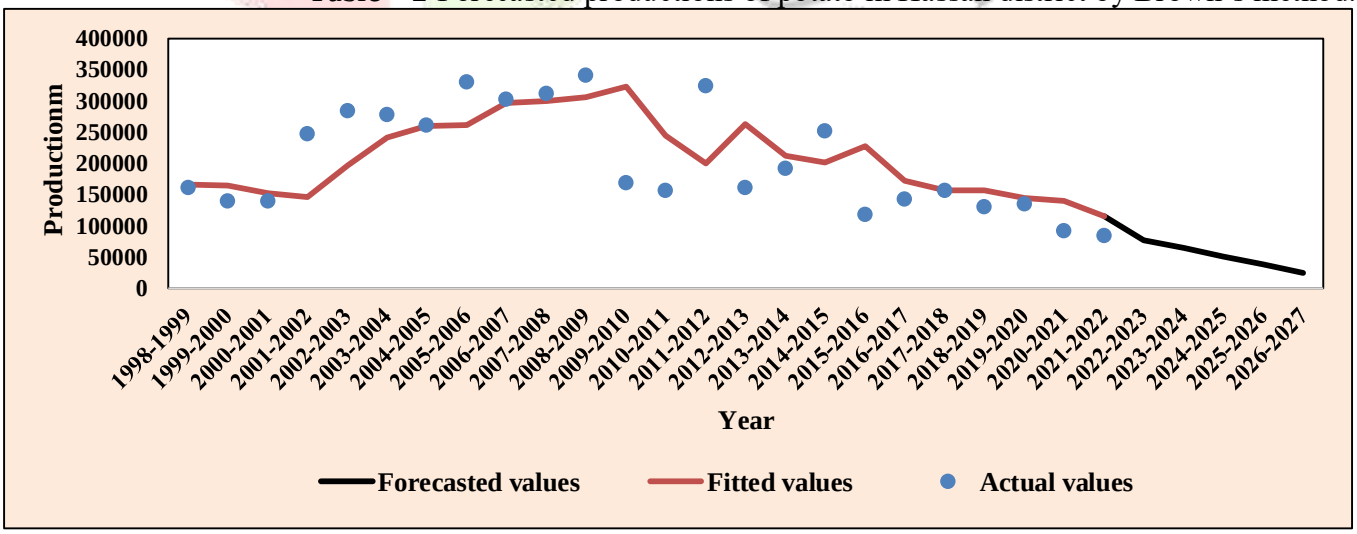
Table 1: Estimates of parameters of Exponential smoothing methods and adequacy measures for the production of potato in Hassan district.

Constraints	Holt's	**Brown's**	Damped
α	0.20 ^{NS}	**0.27***	0.20 ^{NS}
β	1.00 ^{NS}	**------**	0.99 ^{NS}
φ	-----	**------**	0.88**
RMSE	67419.86	**69765.32**	66541.08
MAPE	25.83	**28.86**	25.09
Normalized BIC	22.50	**22.43**	22.61
L Jung Box Q (p-value)	13.19 (0.66)	**14.67 (0.62)**	15.24 (0.43)

**Significant at 1% level, *Significant at 5% level and NS: Non-Significant.

Above table shows that only Brown's method parameter was found to be significant at five per cent level of significance but damped method has having minimum MAPE and RMSE values as compared to Brown's method but parameters of the damped method are found nonsignificant, hence Brown's method is used for the forecasting of potato production for the period of five years i.e. 2022-23 to 2026-27. Forecasted values indicated in Table 2 and depicting figure shows (Fig. 1) decreasing potato production for next five years. The production of potato is decreasing in Hassan district due to post harvest losses, fungal infection of seed material and climatic factors such as heavy rain during tuber formation so the production is decreasing over a period of time.

Table – 2 Forecasted productions of potato in Hassan district by Brown's method.



Year	2022-23	2023-24	2024-25	2025-26	2026-27
Production (tonnes)	76,672	63,805	50,938	38,071	25,204

Fig. 1: Forecasted productions of potato in Hassan district.

Forecasting performance of potato production in Chikkamagaluru district.

Study shows that only the parameters of Brown's method w found to be significant at the given level of significance, whereas the Holt's linear and Damped trend method parameters were determined to be non-significant. The L Jung Box Q test statistic for all exponential smoothing methods found to be non-significant (p-value>0.05), suggesting that autocorrelation assumption is met (Table 3).

Table 3: Estimates of parameters of Exponential smoothing methods and adequacy measures for the production of potato in Chikkamagaluru district.

Constraints	Holt's	**Brown's**	Damped
α	0.09 ^{NS}	**0.24***	0.01 ^{NS}
β	3.754E-006 ^{NS}	**------**	0.78 ^{NS}
φ	------	**------**	0.98**
RMSE	12523.63	**10598.23**	12505.30
MAPE	191.88	**165.18**	190.09
Normalized BIC	19.14	**19.01**	19.26
L Jung Box Q (p-value)	24.76 (0.07)	**26.93 (0.06)**	24.60 (0.06)

** Significant at 1% level, *Significant at 5% level and NS: Non-Significant.

Above table shows that only Brown's method parameter was found to be significant at five per cent level of significance and having minimum MAPE and RMSE values as compared to other two methods, hence Brown's method is used for the forecasting of potato production for the period of five years i.e. 2022-23 to 2026-27. Forecasted values indicated in Table 4 and depicting figure shows (Fig. 2) increasing potato production for next five years.

Table – 4 Forecasted productions of potato in Chikkamagaluru district by Brown's method.

Year	2022-23	2023-24	2024-25	2025-26	2026-27
Production (tonnes)	72,804	75,566	78,327	81,089	83,851

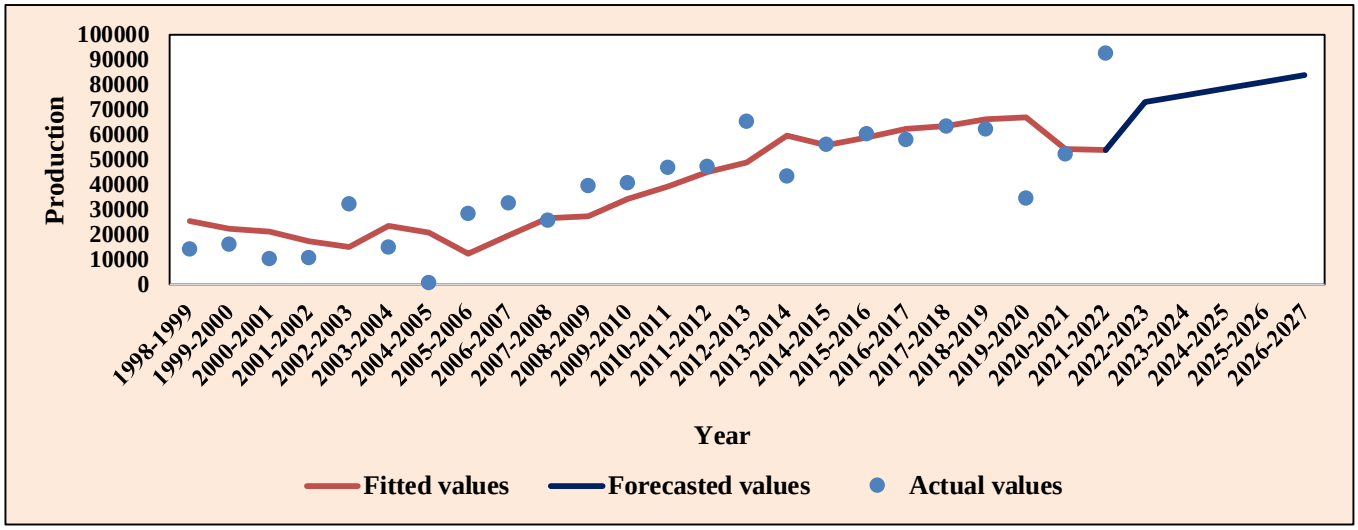


Fig. 2: Forecasted productions of potato in Chikkamagaluru district.

IV. CONCLUSION

The study aimed to forecast potato production in the Hassan and Chikkamagaluru districts of Karnataka using Exponential Smoothing methods. Among the models tested, Brown's one-parameter linear exponential smoothing method provided the most reliable forecasts, with significant parameter estimates and the lowest MAPE and RMSE values. The forecasts revealed contrasting trends for the two districts while Hassan is expected to experience a sharp decline in production due to factors such as post-harvest losses, fungal infections, and adverse climatic conditions.

Chikkamagaluru is projected to see a gradual increase in production over the next five years. These findings highlight the importance of tailored interventions, such as improved disease management and better post-harvest practices, to address the production challenges in Hassan. In contrast, Chikkamagaluru favourable forecast indicates potential for growth, suggesting opportunities for expansion and increased profitability in potato cultivation.

This study provides valuable insights for farmers, policymakers, and the agricultural industry, enabling them to plan and implement strategies for sustainable potato production in Karnataka. The results emphasize the need for localized agricultural policies that address district-specific challenges and capitalize on growth potential, thereby supporting the state's overall agricultural development.

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