IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Application Of Forecasting Technique On Onion Production In Selected Districts Of Karnataka State

Shashwathi, G. M., Dr. A. S. Kamble, K. Rashmi, Thanesh Patel, G. S.

M. Sc (Agri.) Student, Assistant Professor, Assistant Professor, M. Sc (Agri.) Student

Department of Agricultural Statistics, Applied Mathematics and Computer Science, UAS, GKVK, Bangalore, 560065.

Abstract: The present study attempted to forecast the production of onion crop in selected districts of Karnataka. For the research study, the secondary data of 24 years dated from 19998-99 to 2021-22, on the area and production of onion for both Vijayapura and Chitradurga districts of Karnataka was collected from the official website of the Directorate of Economics and Statistics (DES, 2020), Department of Agriculture, Government of Karnataka. The data were analyzed through Exponential Smoothing methods for both districts, the most suitable method was selected based on minimum Root Mean Square Error (RMSE) and Mean Average Percentage Error (MAPE) values. The study showed that Brown's method outperformed well in both districts hence, it is used for the forecasting of onion crop production in both selected Vijayapura and Chitradurga districts of Karnataka for the next five years i.e. 2022-23 to 2026-27. Vijayapura and Chitradurga districts experience increasing production over a period of time.

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

I. INTRODUCTION

Agriculture is the primary source of income for around 58 per cent of India's population. Horticulture also forms an integral part of agriculture dealing extensively with cultivated "Garden crops". Vegetables are essential to any vegetarian meal, as most people 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.

The most widely cultivated species of the genus Allium is the onion (*Allium cepa* L., from the Latin cepa meaning "onion"). Asia is the origin of the onion. This plant is allied to leek, scallion, garlic, and chives. Onions are widely cultivated and used around the world. These vegetables can be cooked or made into pickles and chutneys. Generally, they are consumed raw as a vegetable or as part of cooked savory dishes. If chopped, they give off a pungent smell, and some of their fumes can cause eye irritation. Onions get their pungency from a substance called allyl-propyl disulfide.

Cultivated in 140 countries covering a land area of 54.8 lakh hectares, onions give a yield of 1045.54 lakh tons product, which would make them the third most valuable vegetable in the world after potatoes and tomatoes. The average productivity per hectare in the world stands at 23.06 tons. (FAOSTAT, 2020)

India is the second-largest onion producer in the world. Onions, available throughout the year, are reputed for their pungency. India is the world's second-largest country in terms of land size and output, after China. The production figure for 2022 is 1.94 million hectares of sowing and the resultant 31.69 million metric tons of onion harvest. The major onion-producing states are Maharashtra, Karnataka, Gujarat, Uttar Pradesh, Orissa, Tamil Nadu, Madhya Pradesh, and Bihar. As far as the dimension (2.60 lakh hectares) and yield (126.46 lakh metric tonnes) are concerned, Maharashtra is leading. Gujarat leads in productivity with 25.50 tons of production per hectare. (National Horticulture Board, 2022)

The area under onion in Karnataka is 2.39 lakh hectares, with a production of 27.79 lakh tonnes. Various districts where the major production of onions is carried out are Vijayapura, Chitradurga, Bagalkot, Bellary, Gadag and Dharwad in Karnataka. The major onion-producing regions in Karnataka are Vijayapura (4,93,775 MT), Chitradurga (4,50,469 MT), Bagalkot (3,02,319 MT), Bellary (1,14,312 MT), Gadag (94,004 MT) and Dharwad (29,717 MT). (DES, 2020)

Most of the previous studies relating to the performance of agriculture in Karnataka have been made at the aggregate level. This study will provide information regarding the forecasting performance concerning the production of onion in the Vijayapura and Chitradurga districts of Karnataka. A district-level detailed study would be extremely beneficial to policymakers to formulate relevant and appropriate agricultural policies and programs for all the districts.

Keeping this in background and reference, the study was undertaken to forecast the production of onion in the Vijayapura and Chitradurga districts of Karnataka.

II. METHODOLOGY

2.1 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 Vijayapura and Chitradurga district of Karnataka state, for analysing the forecasting performance with respect to production of potato crop for the successive five years i.e. 2022-23 to 2026-27.

2.2 Research Data:

The secondary data pertaining to area and production of onion in Vijayapura and Chitradurga 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 (DES).

2.3 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.

2.3.1 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).

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

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

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

(Aishwarya *et al.*, 2023)

2.3.2 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.

y_{t-1}: Observation data for the time t-1.

α: Smoothing constant. The constant α has the value between 0 and 1.

(Vinay *et al.*, 2024)

2.3.3 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)

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

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

$$\text{Forecast: } F_{t+m} = L_t + m b_t \textstyle\sum_{i=1}^{h} \varphi^i \quad \ldots (9)$$

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.

(Bhagat and Jadhav, 2021)

2.3.4 Model adequacy checking:

a) The coefficient of determination (R^2):

$$R^2 = \frac{RSS}{TSS} = 1 - \frac{ESS}{TSS} \quad \ldots (10)$$

Where, ESS = Error sum of squares, RSS = Regression sums of squares and TSS = Total sum of squares.

b) Root Mean Square Error (RMSE):

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (Y_t - \widehat{Y_t})^2}{n}} \quad \ldots (11)$$

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

c) Bayesian Information Criteria (BIC):

The formula for BIC is

$$BIC = K \ln(n) - 2\ln(L(\theta)) \quad \ldots (12)$$

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

III. RESULTS AND DISCUSSION

3.1 Forecasting performance of onion production in Vijayapura district.

The study shows that only the parameters of Brown’s method were found to be significant at the given level of significance, whereas 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 was found to be non-significant (>0.05) at the 5 per cent level, suggesting that the autocorrelation assumption is met (Table-1).

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

	Exponential Smoothening Models		
Constraints	**Holt's Linear Method**	**Brown's Method**	**Damped Method**
∝	0.56*	**0.51***	0.55 NS
β	0.77 NS	**-----**	0.99 NS
φ	------	**-----**	0.90 NS
RMSE	64604.64	**64126.69**	65954.58
MAPE	71.43	**66.49**	71.13
Normalized BIC	22.42	**22.27**	22.59
L Jung Box Q (p-value)	7.66 (0.96)	**6.38 (0.99)**	7.24 (0.95)

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

Table-1 depicts that only Brown's method parameter was found to be significant at five per cent level and having minimum MAPE and RMSE values as compared to other two methods considered. Hence Brown's method is used for the forecasting of onion crop production for the period of five successive years i.e. 2022-23 to 2026-27. Forecasted values specifically indicated in Table-2 and showed in figure-1 revealing increasing onion production for next five years. The production of onion crop is increasing in Vijayapura district over a period of time.

Table-2: Forecasted productions of onion crop in Vijayapura district by Brown's method.

Year	2022-23	2023-24	2024-25	2025-26	2026-27
Production (MT)	6,12,846	7,01,584	7,90,321	8,79,059	9,67,797

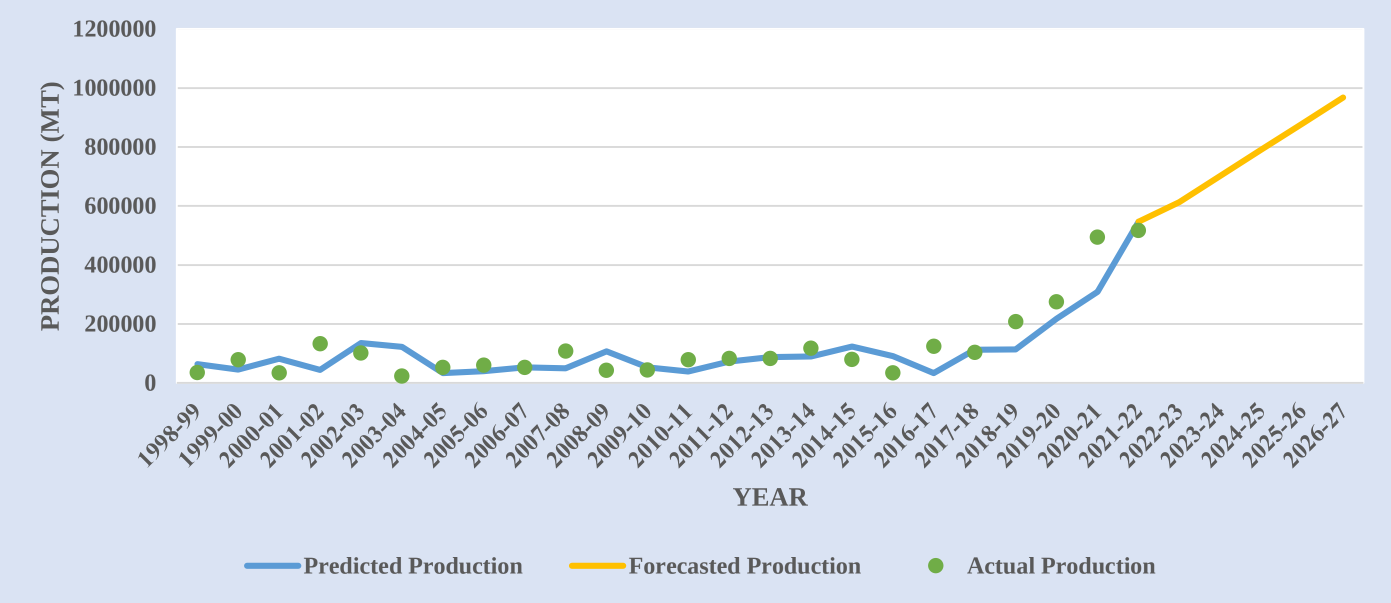

Fig.1: Forecasted production of onion in Vijayapura district

4.2 Forecasting performance of onion production in Chitradurga 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 (>0.05) at the 5 per cent level , suggesting that autocorrelation assumption is met (Table-3).

Table-3: Estimates of parameters of Exponential smoothing methods and adequacy measures for the production of onion in Chitradurga district.

Constraints	Exponential Smoothing Methods		
	Holt's Linear Method	Brown's Method	Damped Method
∝	0.59**	**0.29****	0.31 NS
β	4.77e-06 NS	-----	0.99 NS
φ	------	-----	0.74 NS
RMSE	64097.09	**63873.22**	65103.79
MAPE	32.20	**28.55**	29.54
Normalized BIC	22.40	**22.26**	22.57
L Jung Box Q (p-value)	11.09 (0.80)	**12.40 (0.76)**	12.52 (0.64)

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

Table-3 reveals 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 methods, hence Brown's method is used for the forecasting of onion crop 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 onion crop production for next five years. The production of onion is increasing in Chitradurga district over the period of time.

Table 4: Forecasted productions of onion in Chitradurga district by Brown's method.

Year	2022-23	2023-24	2024-25	2025-26	2026-27
Production (MT)	4,26,895	4,51,867	4,76,840	5,01,812	5,26,784

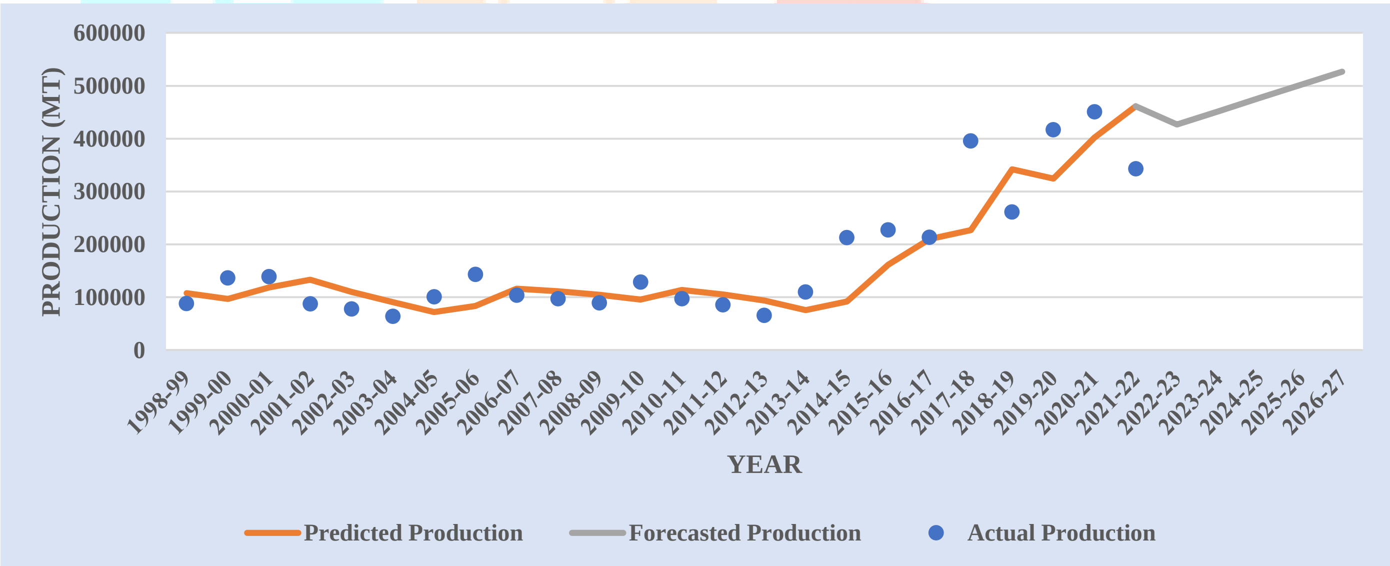

Fig.2: Forecasted production of onion in Chitradurga district

IV. CONCLUSION

The study finally aimed to forecast onion production in the Vijayapura and Chitradurga 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 worked lowest MAPE and RMSE values. The forecasts revealed increasing trends for both Vijayapura and Chitradurga districts.

This findings provides valuable insights for growing farmers, policy makers, and the agricultural industry, enabling them to plan and implement effective strategies for sustainable onion production in Karnataka state.

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 process.

V. REFERENCES

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