emergent
Life Sciences Research

Research Article

Trend analysis of cane crushed and sugar production in Bihar

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Abstract

The goal of this study was to look at the trends in Bihar's cane crushing and sugar production. From 1939 to 2016, time-series data on cane crushed and sugar production was used (78 years). For this reason, three trend analysis models were used: linear, exponential, and quadratic, with the quadratic trend model being the best fit for the current study's trend analysis. A model was considered better if it processed low values of MAPE, MAD, and MSD and high values of R^2_7 and R^2_8. It was suggested that forecasted values have a positive increasing trend and are very close to that of actual values in Bihar as the next coming ten years are showing a good picture of sugar production. The result revealed that using the established model, it is possible to see that anticipated cane crushed and sugar production has constantly increased trends for the next ten years, from 2017 to 2026. The percentage increase in cane crushed ranged from 1.41 to 1.44 during 2017-26. The percentage increase in sugar production ranged between1.42 to1.68 during 2017-26. Farmers are becoming more interested in producing sugarcane in their fields as a result of the excellent profits it provides. These estimates will aid in the formulation of sound policies in Bihar's sugar and cane crushing industries.

Keywords cane crushed, R^2, statistical model, sugar production, trend analysis

Received: 01 March 2022
Accepted: 23 May 2022
Online: 26 May 2022

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Emer Life Sci Res (2022) 8(1): 141-145

E-ISSN: 2395-6658
P-ISSN: 2395-664X

DOI: https://doi.org/10.31783/elsr.2022.81141145

Introduction

India is the world's second-largest producer of sugarcane, after Brazil. Sugarcane is grown in India's major states, including Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu, Bihar, Gujarat, Haryana, Punjab, and Andhra Pradesh. Sugarcane is an essential part of India's economy, providing both employment and income. In our country, approximately 6 million farmers and significant agricultural labourers engage in cane growing. It is India's largest agro-processing industry, employing over 5 million skilled and semi-skilled workers, the majority of whom come from rural areas. On average, white sugar production contributes to roughly 60% of total cane production. Approximately 15-20% of sugarcane is used in the production of gur and khandsari. Sugarcane was grown in an area of 44.4 lakh hectors in India in 2016-17, production 3060.70 lakh tons and productivity of 69.00 tons per hectare [1].

India stands second, after Brazil in sugarcane production. As a result, overall production is low, and sugarcane in sugar mills is scarce. To overcome this deficiency, effects are being developed by introducing high yielding, early maturity and high sucrose content sugarcane varieties

that are also disease and pest resistant. Sugarcane was grown on 2.4 lakh hectares in Bihar in 2016-17, yielding 130.4 lakh tons with productivity of 54.41 tons/ha, which is low in comparison to some of the country's major sugarcane producing states [1]. Sugarcane is a heavy, low-value, weight-losing, and perishable raw material used in Bihar's sugarcane industry. Due to the inevitable loss of reducing sugar, sugarcane cannot be preserved for a long period. Furthermore, it cannot be carried over large distances because of increasing transportation costs, which would boost the manufacturing price, and the sugarcane might dry up along the way. Sugarcane competes with a variety of other food and cash crops such as cotton, oilseed, rice, and so on. As a result, the amount of land available for sugarcane cultivation varies, as does the total sugarcane production. As a result, sugarcane supplies and sugar production in mills fluctuate from time to time. The excessive manufacturing cost is due to the high cost of sugarcane, poor technology, an uneconomic manufacturing method, and a high excise charge. To address these issues, intensive research is needed to increase sugarcane production and introduce innovative technology in sugar mills to increase production efficiency. Costs of production can also be decreased by properly utilizing industry by-products. Bihar is very low in cane crushed and sugar production of sugarcane in India, respectively, Maharashtra, Uttar Pradesh, Karnataka, Tamil Nadu and Gujarat (Table1).

The present research strives to understand an effective trend analysis model to determine past and future patterns in cane crushing and sugar production in Bihar. Policymakers can use trend analysis research to help them make decisions based on future forecasts.

Table 1. Cane crushed and Sugar production of sugarcane in major states of India during 2015-16

Particular	U. P.	Maharashtra	Karnataka	Tamil Nadu	Gujarat	Bihar	India
Cane crushed (% of total)	27.26	31.45	15.94	6.50	4.75	2.17	100
Sugar prod. (% of total)	27.22	33.52	16.11	5.42	4.65	2.00	100

Methodology

From 1939 to 2016, time-series data on cane crushed and sugar production in Bihar was used in the study (78 years). The data was compiled from various issues of Indian Sugar published by ISMA (Indian Sugar Mills Association), New Delhi, and analyzed using Minitab Software and Microsoft Excel. For this investigation, the linear, exponential, and quadratic trend analysis models were used [2-8]. To test goodness-of-fit statistics, the study considered the stationary R-squared value. This statistic estimates the proportion of the total variation in the series explained by the model and is preferable to ordinary R-squared when there is a trend or seasonal pattern [9]. The most accurate model was chosen using four accuracy metrics: Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD), Mean Squared Deviation (MSD), and R^2. Smaller MAPE, MAD, and MSD values, along with a higher R2 and clearly show a well-fitted model with a low number of forecasting errors [6, 10]. This involved in the study's best fit was ultimately determined to be the quadratic model and it was used to forecast cane crushed and sugar production in Bihar for the years 2017-2026.

Model of Linear Trend: $Y_t = \beta_0 + \beta_1 t + e_t$

Model of Quadratic Trend: $Y_t = \beta_0 + \beta_1 t + \beta_2 t^2 + e_t$

Model of Exponential Trend: $Y_t = \beta_0 \times \beta_1 t \times e_t$

where,

β_0 = The constant, β_1 and β_2 = The coefficients, t = Value of the time unit, e_t = The error term

Statistical Parameters

$MAPE = \sum \{(Y_t - \hat{Y}_t) / Y_t\} / n \times 100 \ (Y_t \neq 0)$
$MAD = \sum (Y_t - \hat{Y}_t) / n$
$MSD = \sum (Y_t - \hat{Y}_t)^2 / n$

where,
Y_t= Actual value at time t, $\hat{Y}_t$ = Fitted value, n = Number of observations

The coefficient of determination (R^2) has been inconsistently used to properly assess the goodness of fit of the existing non-linear model. Because the original model is non-linear, logarithmic transformations are used to transform it into a linear model. This value, R^2 is a measure of the model's goodness of fit only. However, the same value is incorrectly interpreted as a measure of the original model's goodness of fit [11].

Results and Discussion

Time series data and estimated trends of cane crushed and sugar production in Bihar have been presented in Table 4 and Figures 1.

Selection of a cane crushing forecasting model

The results of the data presented in Table 2 revealed that precision measures are suitable in the model of quadratic trend, the model of quadratic trend have chosen over the other two (linear and exponential trend) models for forecasting future trends of cane crushed in Bihar based on the low value of MAPE (26.40), MAD (7.22), MSD (77.96) and high value of R^2_7 (0.9317) and R^2_8 (0.9317) [6, 10-11].

Table 2: Model selection diagnostics for sugarcane crushing in Bihar

Measures of accuracy	Criteria				
	MAPE	MAD	MSD	R^2_7	R^2_8
Linear trend model	26.78	7.44	82.67	0.9275	0.9275
Exponential trend model	25.39	7.35	81.49	0.9286	0.8526
Quadratic trend model	26.40	7.22	77.96	0.9317	0.9317

Sugar production forecasting model selection

Table 3 explains the values of accuracy measures for sugar production in Bihar are suitable in the model of quadratic trend in comparison to the model of linear trend and model of exponential trend, based on low values of MAPE (25.22), MAD (0.64), MSD (0.61) and high values of R27 (0.9373) & R28 (0.9373). (0.9373). As a result, in this study, the quadratic model was used to forecast future sugar production in Bihar.

Table 3. Diagnostics for model selection in sugar production in Bihar

Measures of accuracy	Criteria				
	MAPE	MAD	MSD	R^2_7	R^2_8
Linear trend model	26.29	0.68	0.67	0.9307	0.9307
Exponential trend model	25.15	0.68	0.66	0.9317	0.8563
Quadratic trend model	25.22	0.64	0.61	0.9373	0.9373

Forecasted trends for sugarcane crushed in Bihar during 2017-26

Following the fitting of the appropriate model, subsequent estimation was done to find the forecasted values for cane crushed and sugar production of the Bihar sugarcane crop. The goal was to envisage the future value with limited errors [12]. Actual, fitted and predicted cane crushed values in Bihar with a 95% prediction interval. According to the findings, assuming current cane crushing growth rates are maintained, sugarcane crush in Bihar will be 50.01, 50.73, 51.46, 52.20, 52.95, 53.71, 54.48, 55.26, 56.04, and 56.84 lakh tons over the next ten years. It is shown in Figure 1, for the next ten years, 2017-26, with a continuously increasing trend (Table 4). The availability of high yielding cultivars, proper input utilization, and timely availability of inputs for sugarcane in Bihar have all contributed to a positive increase in cane crushed.

Table 4. Forecasted cane crushed and sugar production in Bihar during 2017-26

Forecast years	Cane crushed (lakh tonnes)	% increase in Cane crushed	Sugar production (lakh tonnes)	% increase in Sugar production
2017	50.01	-	4.63	-
2018	50.73	1.44	4.70	1.49
2019	51.46	1.44	4.77	1.47
2020	52.20	1.44	4.85	1.68
2021	52.95	1.44	4.93	1.65
2022	53.71	1.43	5.00	1.42
2023	54.48	1.43	5.08	1.60
2024	55.26	1.43	5.16	1.57
2025	56.04	1.41	5.24	1.55
2026	56.84	1.43	5.32	1.53

Forecasted trends of sugar production in Bihar during 2017-26

The anticipated sugar production levels at the 95 percent prediction interval are shown in Figure 1b. Sugarcane output in Bihar will be 4.63, 4.70, 4.77, 4.85, 4.93, 5.00, 5.08, 5.16, 5.24, and 5.32 lakh tons accordingly with a continuously increasing trend (Table 4) in the years 2017-26 if current sugar production growth rates are maintained. Positive increase in sugar production due to timely harvested and transportation of sugarcane for the mill in Bihar.

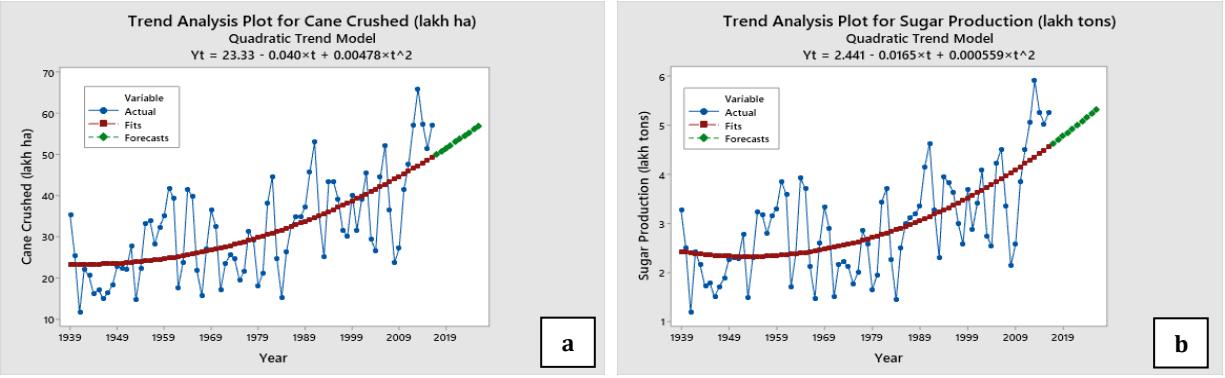

Figure 1. (a) Forecasted trends of sugarcane crushed in Bihar during 2017-26
(b) Forecasted trends of sugar production in Bihar during 2017-26

The data presented in Table 4 on forecasted cane crushed and a sugar production trend shows a positive increase. The percentage increase in cane crushed ranged from 1.41 to 1.44 during 2017-26. The percentage increase in sugar production ranged from 1.42 to 1.68 during 2017-26.

Conclusion

A quadratic model is a useful tool for estimating the magnitude of any variable. Depending upon, the best accuracy measures approaches, a quadratic trend model was built in this work. The results demonstrated that using the established model, it is possible to see that anticipated cane crushed and sugar output have constant increasing trends for the next ten years, from 2017 to 2026. The rising trend indicated that farmers' desire to grow more sugarcane in their fields is driven by the high returns. Researchers may use the model to forecast sugarcane crushing and sugar production in Bihar, according to the model.

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