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Analysis of Trends and Forecast of Minimum Support Price (MSP) in India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This present study was initiated with the objective of analysing the trends in MSP and its forecast to enhance production by providing fair price to the farmers there by ensuring food security and sustainable development of agriculture in the country in view of changing domestic and international

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market dynamics. The study revealed a significant growth in MSP and has steadily increased over the years for cereals, pulses and oilseeds which highlighted the growing importance of these crops in achieving food security in the country. The increase in MSP is mainly attributed to escalating factor prices in addition to global price factors which was observed during 2007-08, 2012-13 and during 2017-18 with the recommendation of M S Swaminathan Committee due to no parity between factor and product prices coupled with weather-related challenges contributed to rise in MSP across crops. The MSP in India is significantly rising for all the selected crops reflecting the Government's commitment to support and protect the income of farmers. To capture the fluctuations and trends in MSP for all the selected crops, the ARIMA model was employed from the year 1998 to 2023 and evaluated the model's goodness of fit, with R^2 values of 0.72 for paddy-C, 0.79 for paddy-A, 0.94 for maize, 0.82 for jowar, 0.85 for ragi, 0.90 for red gram, 0.78 for Bengal gram, 0.86 for groundnut, 0.88 for cotton medium staple, and 0.89 for cotton long staple indicated a strong ability to explain the variance in MSP. The accuracy and suitability of the ARIMA model for forecasting the MSP of selected crops were assessed, with potential for improvement in terms of RMSE and MAE for the year 2023-2030. This suggests that the ARIMA model is a suitable choice for forecasting MSP, given its accuracy and simplicity, thereby providing valuable insights for future agricultural policy planning.

Keywords: Minimum support price (MSP); auto-regressive integrated moving average (ARIMA); FB prophet; root mean squared error (RMSE); mean absolute error (MAE).

1. INTRODUCTION

The success of the Green Revolution in the late 1960s stands as a pivotal moment in India's agricultural history. This achievement was chiefly attributed to a strategic three-pronged approach, involving the adoption of high-yielding seeds, chemical fertilizers, robust extension services and the establishment of guaranteed market support mechanisms [1-2]. The support price program has played a vital role in shielding farmers against sudden price fluctuations. Government intervention through setting minimum guaranteed prices ensured the market stability and provided insurance to the farmers. Until mid-1970s, the Government of India announced two types of administered prices: Minimum Support Price (MSP) and Procurement Prices.

Over time, MSP evolved into a comprehensive mechanism, serving as a reference point for determining market prices and stabilizing prices for various agricultural commodities [3]. Annually, the Government of India notifies MSP for 23 commodities, including 14 kharif, 7 rabi and 2 cash crops, based on recommendations from the Commission for Agricultural Costs and Prices (CACP) [4]. The estimation of MSP relies on a scientific approach, incorporating data on cultivation costs gathered through field surveys conducted by the Directorate of Economic and Statistics under the Ministry of Agriculture & Farmers' Welfare (MoA&FW).

The incentives provided through MSPs have significantly contributed to India's increased food grain production, particularly during the Green Revolution era. By guaranteeing farmers a fair price before the sowing season, MSP incentivize higher investments and production of agricultural commodities [5]. However, recent years MSP policy is facing criticism from various stakeholders, including farmers and proponents of free trade. Challenges arise due to discrepancies between MSP and market prices, as well as domestic demand-supply dynamics [6]. Against this backdrop, the present study aims to elucidate the trends and forecasts in MSPs in India, offering insights into the factors influencing MSP determination and their implications for crop profitability. Through a comprehensive analysis, this research seeks to contribute to the ongoing discourse on agricultural pricing policies and their role in ensuring food security and sustainable agricultural development in the country. Accurate price forecasting is crucial for the Government to take proactive steps and decide various policy measures such as adjusting MSP so that farmers receive a fair price for their produce [7].

2. METHODOLOGY

The crops included in the study were classified into major crop groups, adhering to the standardized categorization system implemented by the Directorate of Economics and Statistics (DES), Karnataka. The major crop groups selected for the research encompass cereal crops (paddy, jowar, maize, and ragi), pulse crops (redgram and bengal gram), oilseed crop (groundnut), and commercial crop (cotton). The data was collected from Commission for Agricultural Costs and Prices (CACP), Ministry of Agriculture and Farmers Welfare, Government of India (GOI) to analyse the trends in MSP in India from 1998-99 to 2022-23 as well as to forecast for 2023 to 2030.

Compound Annual Growth Rate analysis (CAGR): CAGR, is the mean annual growth rate over a specified period of time longer than one year. Growth function was used to calculate the growth rate in MSP over the years. Therefore, the growth in the MSP in study area was calculated using the exponential growth function of the form:

$$Y_t = ab^t e^u \text{……………………} \quad (1)$$

Where,

Y_t - Dependent variable
a - Intercept (constant)
b: Regression coefficient
t: Years (1, 2, ….n)
u_t: Disturbance term for the year t

The equation (1) was transformed into log linear function for calculation purpose and was computed using the Ordinary Least Square (OLS) technique. The compound growth rate (g) in percentage was then estimated from the relationship,

$$g = (\{\text{Antilog of ln b}\} - 1) * 100 \quad (2)$$

2.1 Forecasting Method

2.1.1 Linear regression

Linear regression is the most basic predictive algorithm used to predict the output of a given data by learning from the training data fed to it and is very simple to implement. In simple words, it predicts the dependent variables by learning from independent variables. This can be done by using the help of some regression estimates which explain the variation in the dependent variable due to the independent variables [8].

$$Y = a * X_1 + b * X_2 + c * X_3 + \cdots + X_n + e \quad (3)$$

Where,

$X_1, X_2, \dots X_n$ are the independent variables
Y - Dependent variable
e - Error term

2.1.2 Exponential smoothing model

Exponential smoothing is a method for smoothing time series data for analyses. It is widely used in predicting the values for a given time series data [8]. The actual and forecast values are considered in this method along with a weight parameter alpha (α) which is given as below,

$$F(t) = \alpha * A(t) + (1 - \alpha) * F(t) \dots\dots\dots \quad (4)$$

Where,

$F(t)$ - Forecasted values at time t
$A(t)$ - Actual values at time t

2.1.3 ARIMA model

Auto Regressive Integrated Moving Average (ARIMA) is a statistical analysis model utilized for forecasting future trends in time series data. The model is denoted as ARIMA (p, d, q), where 'p' signifies the order of auto-regression, 'd' represents the degree of differencing, and 'q' indicates the order of the moving average component. This is also known as Box-Jenkin's methodology, focuses on fitting a mixed ARIMA model to the dataset, with the primary goal of identifying the underlying stochastic process of the time series and making accurate predictions for future values [9].

In ARIMA model, it is crucial to understand the backshift operator B, a helpful notational device when dealing with lags of a sequence [10]. For a time-series, (Y_t) the lagged series is denoted by $BY_t = Y_{t-1}$ and similarly, $B^k Y_t = Y_{t-k}$.

The ARIMA model contains three parameters (p, d, q) and can be represented as

$$(1 - B)^d Y_t = \mu + \Phi(B)(1 - B)^d Y_t = \mu + \Phi(B)Z(t) + \theta(B)\varepsilon_t \dots \quad (5)$$

Where,

$\Phi(B)$ is the autoregressive operator of order p, that is,

$$\Phi(B) = 1 - \phi_1 B - \phi_2 B^2 - \cdots - \phi_p B^p$$

$\theta(B)$ is the moving average operator of order q, that is,

$$\theta(B) = 1 + \theta_1 B + \theta_2 B^2 + \cdots + \theta_q B^p$$

Z_t is a white noise process with zero mean and constant variance σ^2
ε_t is the error term

2.1.4 FB-Prophet model

The FB-Prophet model was developed by Facebook's data science research team using a time-series model that can decompose. Since it is a time series model, it is not very effective for making other predictions. The model is developed on the examination of three components including trends, seasonality, and holidays. The technique is built on an addictive-regressive method., with the first component being the trends which simulates non-periodic changes in the time series data; the second component is seasonality which describes nonlinear data behaviour on a daily, monthly, or yearly basis; and the third component takes into account the impact of holidays, which improves its accuracy [11]. The model expressed as,

$$y(t) = g(t) + s(t) + h(t) + \varepsilon(t) \text{ .... (6)}$$

Where,

g(t) - Trend of the time series data
s(t) - Seasonal pattern
h(t) - Holiday influence
ε(t) – Error term

2.1.5 Model evaluation metrics

Evaluation metrics are key to assessing the performance of statistical or machine learning models to understand how well a model is performing by comparing the predicted values with the observed values. The reliability of forecasted values based on the selected model was checked by computing mean absolute error (MAE), mean squared error (MSE), mean absolute percentage error (MAPE), root mean square error (RMSE).

- **Mean Absolute Error (MAE):** The MAE is one of the simplest regression metrics that is easy to understand and compute. By calculating the average of absolute differences between predicted and observed values, it provides an intuitive measure of prediction error magnitude, which states the difference between the observed (Y_i) and forecasted (F_i) values for case i and is given by,

$$\text{MAE} = \frac{1}{n}\sum_{i=1}^{n} |Y_i - F_i|$$

- **Mean Squared Error (MSE):** MSE quantifies the average squared difference between predicted values and actual observed values and is given by,

$$\text{MSE} = n^{-1}\sum_{t=1}^{n}(\sigma_t^2 - \hat{\sigma}_t^2)^2$$

- **Mean Absolute Percentage Error (MAPE):** The MAPE is used when it is important to represent the prediction error in terms of the relative size of the observed value. This can be helpful in situations where the scale of the data is relevant and stated as,

$$\text{MAPE} = \frac{1}{n}\sum_{i=1}^{n} \left|\frac{Y_i - F_i}{Y_i}\right| \times 100$$

- **Root Mean Square Error (RMSE):** The RMSE is a powerful and commonly used regression metric that penalizes large errors due to squaring the differences. The RMSE makes is particularly helpful when large errors are especially undesirable and is given by,

$$\text{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} (Y_i - F_i)^2}$$

- **R-squared:** The R-squared is employed when we are interested in explaining the proportion of variance captured by the model. The R-squared is a key metric for understanding how much of the target variable's variability can be explained by our model and it is defined as,

$$\text{R-squared} = 1 - \frac{\sum_{i=1}^{n} (Y_i - F_i)^2}{\sum_{i=1}^{n} (Y_i - \bar{Y})^2}$$

3. RESULTS AND DISCUSSION

3.1 Trends in Minimum Support Price (MSP)

Growth in MSP in India: The Minimum Support Price (MSP) in India is significantly rising for all the selected crops reflecting the Government's commitment to support and protect the income of farmers. The Compound Annual Growth Rate (CAGR) computed for the selected crops in Karnataka for the period from 1998-99 to 2021-22 is presented in Table 1. In 1998-99, the CAGR of MSP for paddy common and grade A, registered a growth of 7.26 and 7.01 per cent which is significant at one per cent, respectively indicating a substantial increase in MSP. The period of 1990s experienced a higher growth in paddy prices. The rise in production cost is the important factor behind this increased growth in MSP. These results are in similar line with the study conducted by Ali et al. [12] reported that under the falling international prices, the MSP was modified after 2000 and the growth in MSP slowed down sharply during 2000-05. The consequent fall in profitability again forced the Government to raise MSP substantially. Singh et al. [13] highlighted the positive growth in production and MSP for wheat and paddy, with paddy at 7.67 and 1.71 per cent and wheat at 6.98 and 2.04 per cent, respectively. This highlights how increasing production and MSP can lead to enhanced benefits for farmers.

The MSP for maize had shown a significant increase between 1998-99 (Rs. 390/q) to 2021-22 (Rs.1962/q). The CAGR of MSP for maize between the same period was 7.66 per cent significant at one per cent level. Similarly, jowar (Hybrid) had shown significant growth in MSP with 9.65 per cent during the same period. The factors including rise in population growth, changing dietary pattern, and industrial usage (animal feed or ethanol production) impacted the increase in demand for maize. Rising production costs including expenses on seeds, fertilizers, pesticides and labour necessitated the increase in MSP to maintain farmers profitability. The results are in similar line with the study conducted by Kumar et al. [14].

The growth in MSP for ragi between 1998-99 to 2021-22 observed a CAGR of 10.62 per cent which was statistically significant at one per cent level. This indicated that the Government of India is providing better prices to support millet growers. While during 1998-99, the MSP for ragi, maize and jowar was same at Rs. 390 per quintal. Ragi had witnessed the highest growth among the cereal crops, reaching Rs. 3578 per quintal during 2021-22. This divergence in MSP trends was mainly attributed to the factors such as rise in demand, growing awareness about its nutritional value and its suitability to adopt to rainfed conditions. Mahto and Patil [15] reported similar results stating that, in dryland areas finger millet is an important crop for small and marginal farmers, the Government policies and market forces played a role in driving up the MSP for ragi, recognizing its significance in ensuring food security and supporting the income of ragi growers.

The CAGR in MSP among pulses was highest in redgram (9.33%) followed by bengal gram (7.26%). The Government of India launched National Food Security Mission (NFSM) to increase pulses production. Anonymous [16] reported a similar result stating that the recent hike in MSP ranging from 15 to 38 per cent for rabi crops and the Government also created a contingency plan to boost the output of rabi pulses which led to area expansion and productivity enhancement of pulses. The MSP for groundnut had witnessed a significant increase between 1998-99 to 2021-22. The CAGR for groundnut MSP registered 8.18 per cent growth over the period which was statistically significant at one per cent level.

Table 1. CAGR of Minimum Support Price (MSP) of selected crops in India (1998-2022)

Crop	Growth Rate (%)	t-value	SE	R^2	Adj. R^2
Paddy- Common	7.26***	26.71	0.002625	0.968	0.967
Paddy- Grade A	7.01***	26.49	0.002558	0.968	0.966
Maize	7.66***	29.91	0.002467	0.974	0.973
Jowar- Hybrid	9.65***	25.49	0.003614	0.965	0.964
Ragi	10.62***	25.13	0.004015	0.964	0.963
Redgram	9.33***	22.83	0.003907	0.957	0.955
Bengal gram	7.26***	32.39	0.002456	0.978	0.977
Groundnut	8.18***	24.52	0.003205	0.963	0.961
Cotton- Medium staple	6.63***	22.70	0.002827	0.957	0.955
Cotton- Long staple	6.26***	22.95	0.002643	0.958	0.956

*Note: 1. ***indicates significance level at 1 per cent*
2. SE – Standard Error

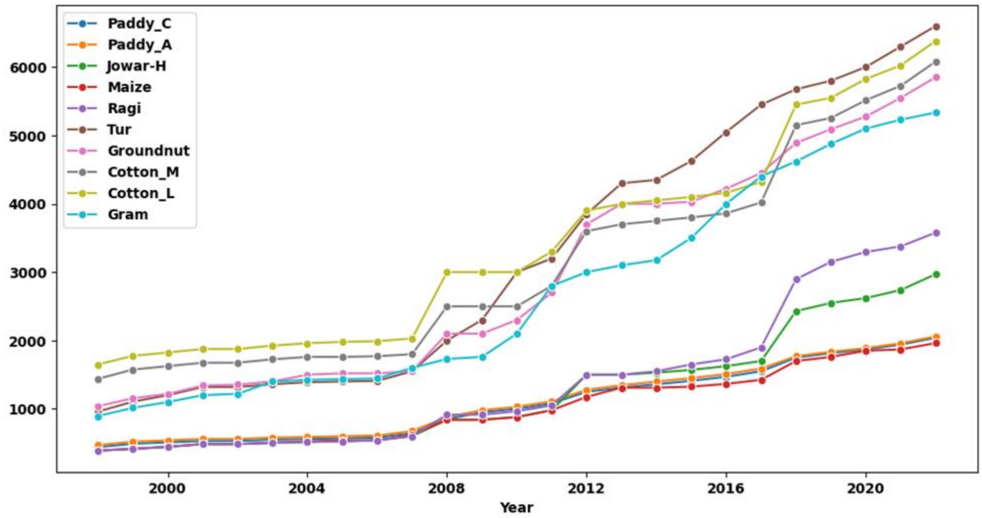

Fig. 1. Trends in minimum support price in india for selected crops (1998 to 2022)

The CAGR for medium staple and long staple cotton was 6.63 and 6.26 per cent over the period which was statistically significant at one per cent level indicating a substantial increase in MSP. These results are in similar line with the findings of Geetha and Mahesh [17] reported that the produce was procured by the Government at the announced MSP when the growth in MSP of cotton failed to increase the market price. Thus, interest among cotton growers was protected and influenced to increase the area and production of cotton.

In overall, the MSP is increasing over the years for cereals, pulses and oilseeds keeping in view the food security in mind. The increase in MSP during 2007-08 was due to global food price inflation, higher input costs, and political considerations. Again during 2012-13, due to rising input costs, inflationary pressures, political considerations, and crop damage due to weather events such as drought resulted in increase in MSP. During 2017-18 due to the low farm prices, rising input prices, weather-related events and growing importance for implementation of Swaminathan Committee recommendations resulted in increase in MSP. The Government wanted to ensure that farmers received a fair price for their crops and also wanted to gain their support ahead of the upcoming general elections (Fig. 1). These findings are on par with the study conducted by Mahto and Patil (2023).

The purpose besides increase in MSP is multifarious to incentivize and motivate farmers to increase acreage, maintain parity with sharp escalation in input costs, to keep pace with rising market prices of crops though market price still exceeded the increased MSP. Indian agriculture till date is heavily dependent on the vagary’s of monsoon, particularly in rainfed areas, play a crucial role in the selection of crops. In addition, the even and timely distribution of rainfall across regions and its withdrawal also play a crucial role in determining the output of any agricultural commodity. The incidence of drought like situations and delayed southwest monsoon during the early Kharif season during 2012 led to decline in sowing of food grains. Although normal rains from late July over many crop producing areas provided some relief and allowed planting to take place, the late start of the planting period is expected to reduce the crop yields.

Forecast of MSP: The findings of exponential smoothing for forecasting MSP are presented in the Table 2 for selected crops in India. The forecast evaluation metrics for MSP of these crops using the exponential smoothing model highlighted the varying performance across selected crops. The model performs well for maize and cotton, it exhibited limitations in capturing MSP fluctuations for other crops such as paddy, jowar, ragi, redgram, bengal gram, and groundnut, as evidenced by relatively high error and negative R^2 value. The model indicated a substantial level of prediction error, as reflected in the RMSE, MAE, MAPE, and MSE values for these crops. These findings implied that the model may not be the most suitable choice for accurately forecasting MSP for these crops. Potential reasons could be the presence of complex and irregular price trends, seasonality or external factors that are not adequately accounted by the model. These findings of the study are in line with the study conducted by Gupta et al. (2021) employed machine learning as well as numerical techniques to find the prediction of MSP of the crops. Hlouskova et al. [18] employed time series analysis with exponential smoothing and the Box-Jenkins autoregressive integrated process moving averages. The results of the study reported that other approaches were recommended for forecasting costs related to crops.

The results of the forecast evaluation metrics for MSP of selected crops in India using prophet model is presented in Table 3. The results of the prophet model do not perform well in forecasting MSP for the crops such as, jowar, ragi, redgram, bengal gram, groundnut and cotton as reflected in the high RMSE, MSE and MAE values followed by negative R^2 values. The model struggled to capture the fluctuations and trends in the MSP data for these crops. Hence, these specific agricultural commodities may need to explore alternative approaches or more sophisticated models to improve predictive accuracy.

The ARIMA model, a time series forecasting method, excludes the auto-regressive (AR) component while including differencing (I) and a first-order moving average (MA) term. Differencing is applied to achieve data stationarity and ensure consistent statistical properties, while the MA term utilizes weighted averages of past data points for predictive accuracy. It's particularly valuable for data displaying a first-order differencing pattern with minimal autocorrelation. Widely applied across various domains, the ARIMA model was employed to predict MSP values from 2023 to 2030, capturing short-term trends effectively by incorporating differencing for data stationarity and the MA term for forecasting.

Table 2. Estimates of exponential smoothening model representing forecast evaluation matrix for MSP of selected crops in India

Crop	**RMSE**	**MAE**	**MAPE**	**MSE**	**AIC**	**BIC**	**R^2**
Paddy-Common	111.96	104.83	5.40	12535.95	177.51	181.68	-0.76
Paddy- Grade A	102.83	96.42	4.91	10575.02	175.72	179.90	-0.48
Maize	16.75	13.82	0.73	280.85	190.44	194.62	0.94
Jowar-Hybrid	216.22	209.51	7.78	46752.93	226.36	230.54	-0.83
Ragi	407.39	389.39	11.80	165971.20	235.05	239.23	-5.93
Redgram	320.69	315.76	5.08	102843.40	227.51	231.69	-0.11
Bengal gram	277.05	223.25	4.25	76759.82	223.93	228.11	-1.60
Groundnut	84.85	79.44	1.46	7200.52	239.23	243.41	0.91
Cotton-Medium staple	132.36	125.63	2.20	17520.05	248.91	253.09	0.80
Cotton-Long staple	36.27	29.13	0.49	1315.90	250.62	254.80	0.98

Note: RMSE- Root Mean Squared Error, MAE- Mean Absolute Error, MAPE-Mean Absolute Percentage Error, MSE-Mean Square Error, AIC- Akaike Info Criterion, BIC-Bayesian Information Criterion

Table 3. Estimates of Fb-prophet model representing forecast evaluation matrix for MSP of selected crops in India

Crop	**RMSE**	**MSE**	**MAE**	**R^2**
Paddy-C	22.76	518.25	17.75	0.92
Paddy- A	30.52	931.75	28.75	0.86
Maize	33.28	943.17	30.50	0.83
Jowar-H	678.69	460631.00	675.00	-17.11
Ragi	1113.05	1238882.00	1112.00	-50.76
Redgram (Tur)	355.26	126213.80	354.25	-0.37
Bengal gram	639.78	409318.50	638.50	-12.89
Groundnut	462.55	213955.50	456.50	-1.59
Cotton-M	973.25	947225.80	965.25	-9.38
Cotton-L	876.85	768867.50	869.00	-7.40

Note: RMSE- Root Mean Squared Error, MAE- Mean Absolute Error, MAPE-Mean Absolute Percentage Error, MSE-Mean Square Error, AIC- Akaike Info Criterion, BIC-Bayesian Information Criterion

Table 4. Forecast evaluation metrics for MSP of selected crops in India using ARIMA model

Crop	RMSE	MAE	MAPE	MSE	AIC	BIC	R^2
Paddy-C	63.87	62.37	3.28	4080.44	222.45	225.04	0.72
Paddy- A	53.47	51.51	2.68	2859.62	220.63	223.62	0.79
Maize	16.53	12.75	0.68	273.37	235.08	237.07	0.94
Jowar-H	66.98	41.50	1.43	4487.00	269.53	271.52	0.82
Ragi	142.34	139.62	4.15	20263.39	278.08	280.07	0.85
Redgram	91.89	77.02	1.28	8444.89	273.44	276.43	0.90
Bengal gram	79.93	70.25	1.38	6389.20	264.59	267.57	0.78
Groundnut	103.63	70.00	1.22	10740.63	280.46	282.46	0.86
Cotton-M	102.76	73.50	1.27	10560.13	289.78	291.77	0.88
Cotton-L	96.24	67.50	1.11	9262.50	291.18	293.17	0.89

Note: 1. RMSE- Root Mean Squared Error, MAE- Mean Absolute Error, MAPE-Mean Absolute Percentage Error, MSE-Mean Square Error, AIC- Akaike Info Criterion, BIC-Bayesian Information Criterion

2. Paddy-C: Paddy-Common, Paddy-A: Paddy- Grade A, Jowar-H: Jowar-Hybrid, Cotton-M: Cotton (Medium Staple), Cotton-L: Cotton (Long Staple)

Table 5. Forecasted MSP for selected crops in India using ARIMA model

Year	Paddy-C	Paddy- A	Maize	Jowar-H	Ragi	Redgram	Bengal gram	Groundnut	Cotton-M	Cotton-L
2022	2081	2088	1962	2838	3398	6599	5349	5660	5892	6210
2023	2149	2156	2028	2940	3524	6831	5534	5853	6078	6400
2024	2217	2223	2093	3042	3649	7063	5719	6045	6263	6590
2025	2285	2291	2159	3144	3774	7295	5904	6238	6449	6780
2026	2354	2358	2224	3246	3900	7527	6089	6430	6634	6970
2027	2422	2425	2290	3348	4025	7759	6273	6623	6820	7160
2028	2490	2493	2355	3450	4150	7991	6458	6815	7005	7350
2029	2559	2560	2421	3552	4276	8223	6643	7008	7191	7540
2030	2627	2627	2486	3654	4401	8455	6828	7200	7376	7730

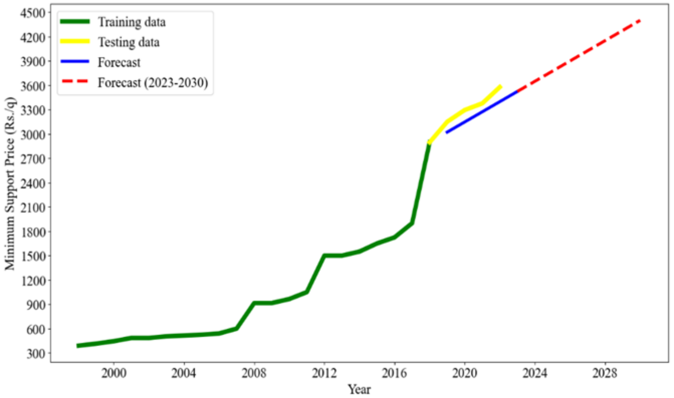

Fig. 2. Forecasted MSP for paddy (common) in India using ARIMA (0,1,1) model

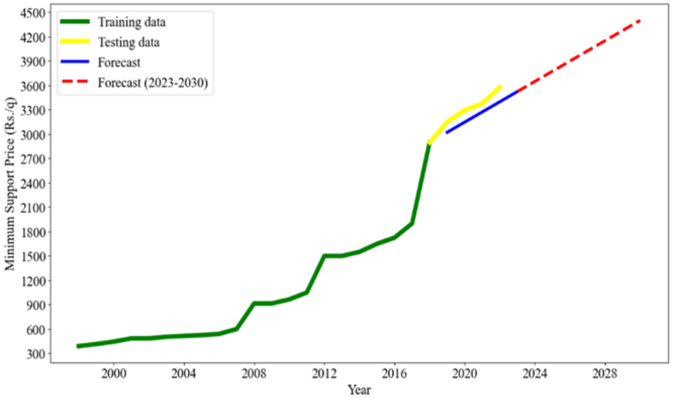

Fig. 3. Forecasted MSP for paddy (Grade A) in India using ARIMA (0,1,1) model

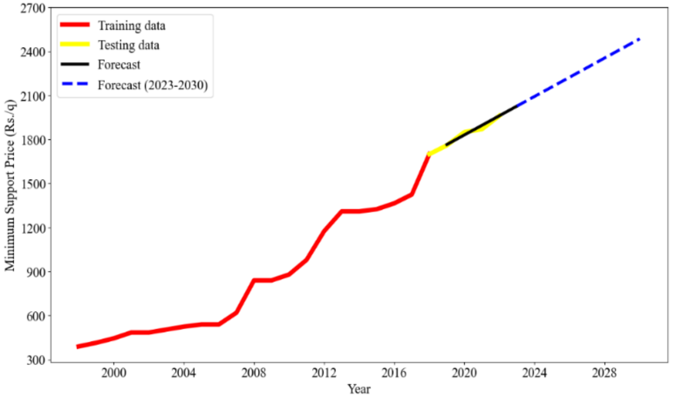

Fig. 4. Forecasted MSP for maize in India using ARIMA (0,1,0) model

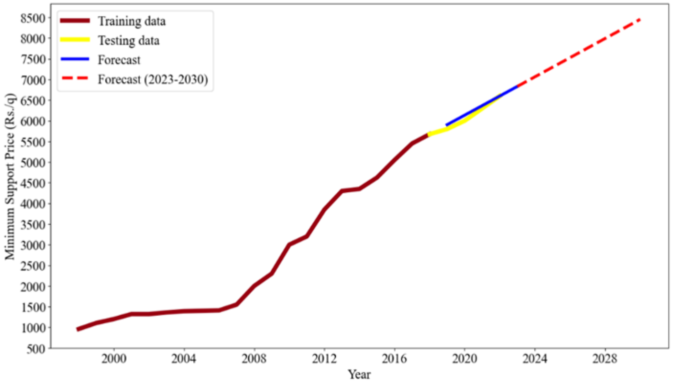

Fig. 5. Forecasted MSP for jowar in India using ARIMA (0,1,0) model

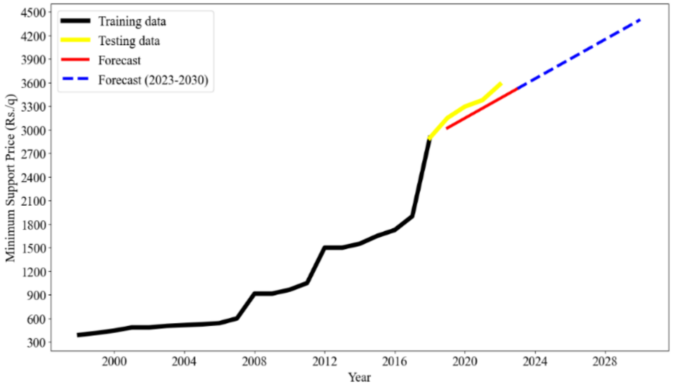

Fig. 6. Forecasted MSP for ragi in India using ARIMA (0,1,0) model

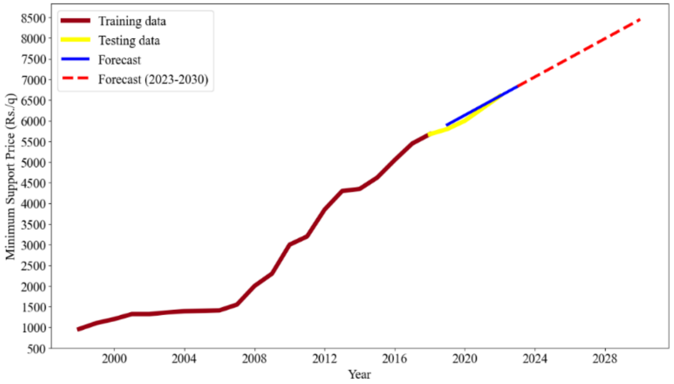

Fig. 7. Forecasted MSP for redgram in India using ARIMA (1,1,0) model

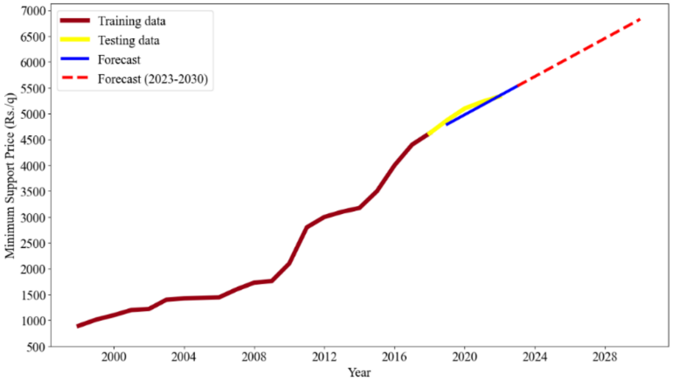

Fig. 8. Forecasted MSP for bengal gram in India using ARIMA (0,1,0) model

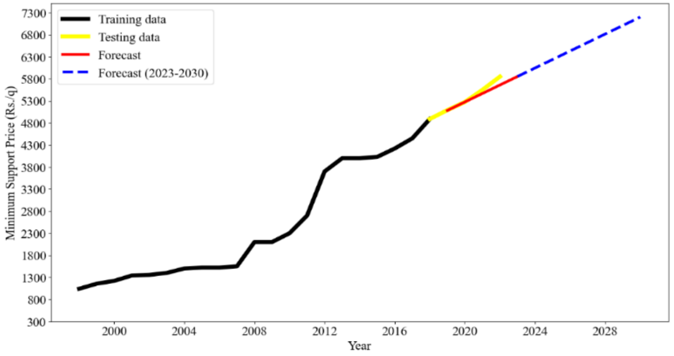

Fig. 9. Forecasted MSP for groundnut in India using ARIMA (0,1,0) model

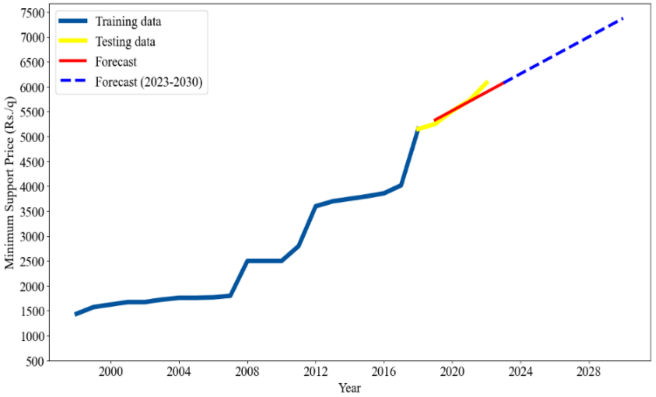

Fig. 10. Forecasted MSP for cotton (Medium staple) in India using ARIMA (0,1,0) model

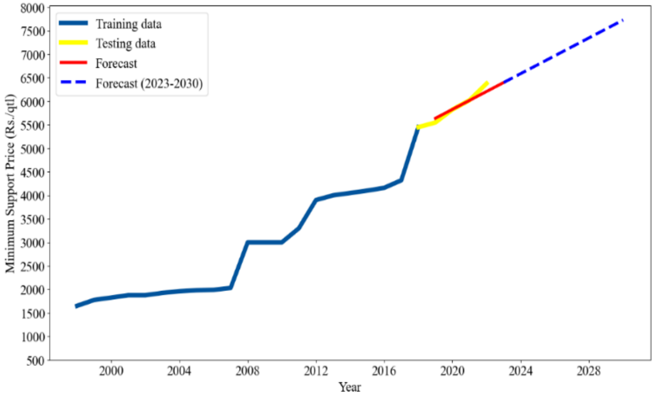

Fig. 11. Forecasted MSP for cotton (Long staple) in India using ARIMA (0,1,0) model

Forecast evaluation metrics for Minimum Support Price (MSP) of selected crops in India, using an ARIMA model is presented in Table 4. These metrics provide valuable insights into the model's performance in predicting crop prices for all the selected crops. All the selected crops exhibited the lowest AIC and BIC values, indicating a better balance between model accuracy and complexity. These criteria suggested that the ARIMA model provided a good fit to the data while maintaining model simplicity for paddy. These metrics collectively evaluated the model's goodness of fit and its explanatory power, with R^2 value of 0.72 in paddy-C followed by paddy-A (0.79), maize (0.94), jowar (0.82), ragi (0.85), redgram (0.90), bengal gram (0.78), groundnut (0.86), cotton medium staple (0.88) and long staple (0.89) showed a better ability to explain the variance in MSP. Overall, these metrics assess the accuracy and appropriateness of the ARIMA model for forecasting MSP for all the selected crops with potential for model improvement in terms of RMSE and MAE, while maintaining a reasonable balance between predictive accuracy and model complexity. This suggested that the ARIMA model was a suitable choice for forecasting MSP, given its ability to strike a reasonable trade-off between accuracy and model simplicity. The findings of the results are in line with the study conducted by Darekar and Reddy [19] wherein they forecasted the price of common paddy for India by using the ARIMA technique.

Forecasting of MSP using ARIMA model: The ARIMA model effectively captured the short-term fluctuations and trends in MSP for all the selected crops in the study, making it a suitable choice for forecasting. The choice of the most appropriate forecasting model varies across different crops, and the performance of the ARIMA model was relatively better, compared to the exponential smoothing and Prophet models (Table 5). However, other models had limitations in forecasting MSP for crops due to the complexity of their price trends. A forecast of MSP for selected crops in India over the next several years, based on an ARIMA model is presented in Fig. 2 to Fig. 11. The values in the table represent the anticipated MSP for each crop from 2022 to 2030. A similar discussion was made by the study Umar et al. [20] wherein authors conducted research on forecasting models and suggested the results of the models were helpful for managing and decision making in planning for the future effectively.

4. CONCLUSION

The growth of MSP has increased steadily over the years for cereals, pulses, and oilseed crops. The forecasting of MSP using ARIMA model was a suitable choice for forecasting MSP compared to other models. The model assessed the accuracy and appropriateness for forecasting MSP for all the selected crops with potential for model improvement in terms of RMSE and MAE. The forecasts hold significant implications for various stakeholders within the agricultural sector. Farmers and agricultural policymakers can leverage this data for planning and budgeting, as it provides insights into expected MSP for selected crops in the study. This knowledge empowers them to make informed decisions about crop selection and resource allocation, enhancing their ability to optimize production and income. Moreover, these forecasts play a crucial role in risk management, reducing price uncertainty and financial risk for farmers, facilitating data-driven decisions that support farmers and ensure food security. Additionally, these forecasts can promote crop diversification, as farmers may shift towards crops with higher expected MSP, thereby fostering agricultural diversity and strengthening the sector's resilience. Overall, the results of the study will help the farmers to make decisions on time of marketing in order to reap maximum benefit.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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