TPM Vol. 32, No. S9, 2025
ISSN: 1972-6325
https://www.tpmap.org/

BLACK GRAM PRICE DYNAMICS IN INDIA: A TIME SERIES INQUIRY INTO TRENDS, VOLATILITY, AND SUSTAINABLE MANAGEMENT

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Abstract: Agricultural commodity prices play a pivotal role in shaping the livelihoods of millions of farmers, influencing food affordability for consumers, and determining national food security strategies. Among these, pulses—and especially Black Gram (Urd bean)—hold significant importance in India's dietary patterns, farming systems, and agro-economy. Known for its high protein content and wide consumption, Black Gram is cultivated primarily in rainfed regions, making it vulnerable to climatic conditions, input availability, and market dynamics (Kumar & Reddy, 2020).
Key Words: Black gram. Price Trend . Price Dynamics. Sustainable Management

1. INTRODUCTION

Over the years, the price of Black Gram in India has experienced notable fluctuations due to a mix of factors including seasonal production cycles, market supply-demand gaps, climatic uncertainties, and policy interventions such as Minimum Support Prices (MSP), import-export controls, and procurement schemes (Ministry of Agriculture & Farmers Welfare, 2023). These variations pose substantial risks and challenges for farmers, especially small and marginal ones, who depend heavily on consistent and remunerative prices to sustain their agricultural livelihoods.

Despite the implementation of various policies, price volatility remains a persistent issue in the pulse sector (FAO, 2021). Sharp increases in prices often benefit traders more than producers, while sudden drops lead to distress sales and income insecurity for farmers. From the consumer perspective, unpredictable price spikes affect affordability and access to essential nutrition. In this context, understanding the long-term behavior of Black Gram prices becomes crucial not only for farmers but also for policymakers, agricultural economists, cooperatives, and market regulators (NABARD, 2021).

This study seeks to fill that gap by providing a time series-based analytical perspective on the price patterns of Black Gram in India over the period 2003–04 to 2022–23. Using tools such as regression analysis, moving averages, and index decomposition methods, the research aims to examine the trend, cyclical, seasonal, and irregular components of price changes (Singh & Sharma, 2019). By doing so, it uncovers deeper insights into how Black Gram prices behave over time and what implications these patterns hold for sustainable price management.

The findings of this study are expected to aid in: developing more effective pricing policies and procurement strategies; guiding farmer advisory services for better income planning; supporting the design of market stabilization schemes; and enhancing awareness among consumers and decision-makers about the forces driving pulse price dynamics.

Ultimately, this research contributes to the broader conversation on ensuring price stability, food security, and farmer welfare in India's evolving agricultural landscape.

2. METHODOLOGY

This study employed a quantitative time-series analysis approach to investigate the price trend of Black Gram in India over a 20-year period (2003–04 to 2022–23). The methodology combines statistical tools like regression and moving average methods (FAO, 2021), and index-based decomposition to uncover trend, cyclical, seasonal, and irregular components of price behaviour. The results were further normalized for relative comparison across time.

2.1 Trend Analysis

A simple linear regression was applied to capture the trend in Black Gram prices over time. The independent variable is the year index, and the dependent variable is the actual price per quintal. The regression trend indicates how prices are expected to evolve over time in the absence of fluctuations.

To identify the long-term trend, a simple linear regression model was applied, where the year index (starting from 0 in 2003–04 to 19 in 2022–23) was used as the independent variable (X) and the actual price per quintal was the dependent variable (Y).

Regression Equation:

The regression model is defined as:

Y = a + bX

Where:

- **Y** = Estimated price (trend value)
- **X** = Year index (0 to 19)
- **a** = Intercept (baseline price)
- **b** = Slope (yearly change in price)

Computed Regression Equation:

Based on the actual data:

Trend Price = 2748.00 + 275.89 × Year_Index

This equation indicates that the base price in 2003–04 was ₹2748.00 and that price has increased approximately by ₹275.89 every year since then.

2.2 Cyclical Variation Index

Cyclical Index is computed as the ratio of actual price to trend price, showing deviation due to market cycles. Cyclical variations reflect medium- to long-term fluctuations above or below the trend due to economic or market cycles (e.g., demand-supply imbalance, market sentiment, export-import conditions).

The **Cyclical Index** is calculated as:

Cyclical Index = (Actual Price / Trend Price) × 100

To enable year-to-year comparison, the values were **normalized** using:

Normalized Cyclical Index = Cyclical Index / Average of all Cyclical Indices

A normalized index >1 indicates a higher-than-average cyclical impact, and <1 shows a lower-than-average impact.

2.3 Irregular Variation

Irregular Index captures the residual component after removing trend and seasonal variations. All indices were further normalised to compare magnitude of variation across years. The Irregular Variation captures the residual or random component left after accounting for both trend and seasonality. It typically reflects unanticipated factors such as policy changes, weather shocks, pandemics, or political instability.

Formula:

Irregular Variation = Actual Price - Trend Price - Seasonal Variation

This too was normalized as:

Normalized Irregular Index = Irregular Variation / Average Irregular Variation

2.4 Moving Average for Seasonal Variation

To estimate seasonal fluctuations, a centred 3-year moving average was used. This smoothed value serves as the benchmark to measure short-term deviations in prices, i.e., seasonal variation. To estimate short-term, periodic fluctuations (seasonality), a 3-year centered moving average (MA) was computed. This smoothens out random noise and provides an estimate of the seasonal baseline.

Formula:

Moving Average_t = (Price_(t-1) + Price_t + Price_(t+1)) / 3

Seasonal Variation is then computed as:

Seasonal Variation = Actual Price - Moving Average

To make comparisons easier across years, we calculated:

Index of Seasonal Variation = (Seasonal Variation / Moving Average) × 100

Normalized Seasonal Index = Index of Seasonal Variation / Average Index

Table 1: Year-wise Black Gram Price Analysis with Trend, Cyclical, Seasonal, and Irregular Indices

Year	Price	Trend Regression	Normalized Cyclical Index	Normalized Irregular Index	Trend MA	Seasonal Variation	Normalized Seasonal Index
2003-04	4203	2748.000	1.521	91.374			
2004-05	3337	3092.826	1.073	13.624	3637.333	-300.333	20.784
2005-06	3372	3437.653	0.975	-3.296	3189.000	183.000	-14.444
2006-07	2858	3782.479	0.751	-42.179	3333.000	-475.000	35.872
2007-08	3769	4127.305	0.908	-14.982	3636.000	133.000	-9.207
2008-09	4281	4472.132	0.952	-7.376	4252.667	28.333	-1.677
2009-10	4708	4816.958	0.972	-3.904	4454.667	253.333	-14.314
2010-11	4375	5161.784	0.843	-26.305	4769.000	-394.000	20.795
2011-12	5224	5506.611	0.943	-8.857	5046.333	177.667	-8.862

2012-13	5540	5851.437	0.941	-9.185	5454.667	85.333	-3.938
2013-14	5600	6196.263	0.899	-16.607	5946.667	-346.667	14.674
2014-15	6700	6541.089	1.018	4.193	6333.333	366.667	-14.573
2015-16	6700	6885.916	0.967	-4.659	7100.000	-400.000	14.181
2016-17	7900	7230.742	1.086	15.973	7546.667	353.333	-11.785
2017-18	8040	7575.568	1.055	10.580	8480.000	-440.000	13.060
2018-19	9500	7920.395	1.193	34.417	8536.667	963.333	-28.405
2019-20	8070	8265.221	0.971	-4.076	9190.000	-1120.000	30.676
2020-21	10000	8610.047	1.155	27.859	8856.667	1143.333	-32.494
2021-22	8500	8954.874	0.944	-8.766	8766.667	-266.667	7.657
2022-23	7800	9299.700	0.834	-27.830			
Source:							

3. RESULTS AND FINDINGS

The price trend of Black Gram in India from the agricultural year 2003–04 to 2022–23 was examined using statistical tools like regression and moving average methods (FAO, 2021), and index decomposition methods. The analysis focused on breaking down the price behaviour into four major components: trend, cyclical, seasonal, and irregular variations. This approach helped in identifying both the long-term movement of prices and short-term fluctuations due to various factors.

The detailed year-wise data and statistical results are presented in **Table 1**.

3.1 Trend Observation

The analysis of Black Gram prices over the 20-year period from 2003–04 to 2022–23 reveals a steady upward trend. This was determined using a simple linear regression model. The regression equation computed from the data is:

Trend Price = 2748.00 + 275.89 × Year Index

This equation shows that in the base year 2003–04 (which is represented as Year Index 0), the expected or trend price of Black Gram was ₹2748 per quintal. According to the trend, the price was expected to increase by ₹275.89 every year. This shows a steady and predictable rise in the price of Black Gram in India, possibly due to factors like increasing production costs, higher demand, inflation, or changes in agricultural policy.

For example, in the year 2003–04, the actual market price was ₹4203, while the trend value was only ₹2748. This means that the actual price was ₹1455 higher than the expected price, suggesting that this year experienced a strong market surge. In contrast, in 2011–12, the actual price was ₹5224, while the trend value was ₹5506.61, which means the actual price was slightly below the expected trend by about ₹283. This indicates a short-term dip in price growth.

A more significant upward deviation was observed in the year 2018–19, where the actual price was ₹9500, while the trend value was ₹7920.39. The difference of ₹1579.61 above the trend shows that the market may have experienced a supply shock or unusually high demand during that year.

On the other hand, in 2022–23, the actual price was ₹7800, while the trend value was ₹9299.70. The actual price was ₹1499.70 lower than the trend, indicating that the price rise slowed down or reversed. This may indicate market correction, surplus supply, or lower demand.

The regression analysis highlights a clear upward trend in prices over time. However, it also shows that actual prices often deviated from the trend in several years. These deviations, both above and below the trend, point to the presence of other influencing factors such as cyclical, seasonal, and irregular elements, which are explored in the following sections.

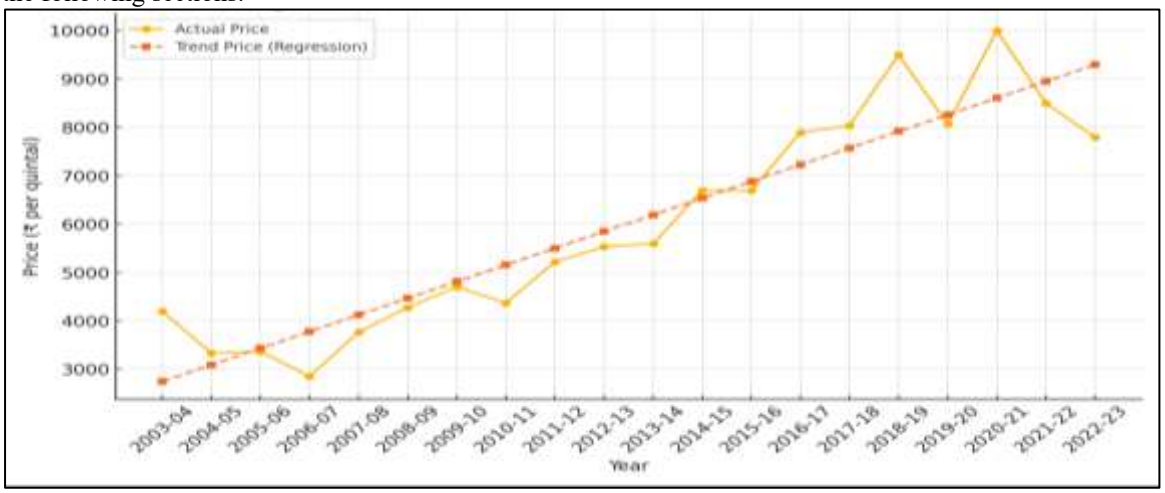

Figure 1 : Actual vs. Trend Price of Black Gram (2003–2023)

Figure 1 shows a comparison between the actual market prices of Black Gram and the trend values estimated using a simple linear regression model. While the overall trend indicates a steady increase in prices over time, several years show significant deviations. For example, in 2003–04 and 2018–19, the prices were well above the trend, while in 2022–23, the price fell below the expected trend level.

This equation clearly shows that prices have been rising in a linear pattern in Black Gram prices over the 20-year period. Starting from an estimated ₹2748 per quintal in 2003–04, the expected price increased by approximately ₹275.89 every year.

3.2 Cyclical Variation

Cyclical variation refers to price changes and their implications that occur due to economic or market-related cycles over a medium- or long-term period. These cycles are different from seasonal changes and are usually caused by factors such as changes in production levels, shifts in demand, market speculation, or government policies.

In this study, the cyclical behaviour of Black Gram prices was analysed by comparing the actual prices with the trend prices derived from regression. The Cyclical Index was calculated as the ratio of actual price to trend price, and then it was adjusted to allow meaningful comparison between years.

The Normalized Cyclical Index helps us understand how much the actual price deviated from the expected trend price in each year. A value greater than 1 means the price was above trend (a positive cycle), while a value less than 1 means the price was below trend (a negative cycle).

In the year 2003–04, the normalized cyclical index was 1.521, indicating a very strong positive deviation from the trend. This suggests that during that year, market conditions were highly favourable, and prices increased well above their expected level. Such high values can be due to a sudden shortage in supply or increased demand.

In contrast, the year 2022–23 showed a normalized cyclical index of 0.834, which was one of the lowest in the 20-year period. This indicates that prices during that year were significantly lower than the expected trend, possibly due to excess production, reduced demand, or other unfavourable market conditions.

Several other years also showed interesting cyclical behavior. For example, 2016–17 had a normalized cyclical index of 1.086, and 2020–21 had 1.155, both of which suggest that the actual prices were higher than the trend. These years may have experienced economic or supply-demand conditions that pushed prices upward. On the other hand, years like 2010–11 and 2013–14 showed values below 1 (0.843 and 0.899 respectively), pointing to downward deviations from the trend.

Overall, the analysis of cyclical variations reveals that Black Gram prices are not only influenced by long-term trends but also by market cycles that cause fluctuations above or below the expected price levels. These cyclical changes play a significant role in determining the income and planning of farmers and also impact pricing strategies in agricultural markets.

3.3 Seasonal Variation

Seasonal variation refers to regular price changes that happen at certain times of the year. These changes are usually caused by predictable patterns such as sowing and harvesting seasons, festivals, climatic conditions, and agricultural cycles. Unlike cyclical variations, which take place over several years, seasonal variations are short-term and occur within a year or in a repeating yearly pattern.

In this study, seasonal variations in Black Gram prices were analysed using a 3-year centered moving average method. This method helps in removing irregular fluctuations and brings out the seasonal effect more clearly. The difference between the actual price and the moving average for each year was considered the seasonal variation.

From the results, it is clear that some years experienced strong seasonal effects. For instance, in the year 2020–21, the seasonal variation was ₹1143.33, which is the highest positive seasonal deviation in the data. This means that during that year, prices were significantly higher than the expected seasonal average. Similarly, 2018–19 also recorded a very high seasonal deviation of ₹963.33. These high values may be due to factors such as delayed monsoons, post-harvest losses, or increased demand during festivals.

On the other hand, some years showed negative seasonal variation, meaning prices were lower than expected. The most notable was 2019–20, where the seasonal variation was –₹1120, indicating that prices were much lower than the seasonal average. Other years like 2015–16 (–₹400) and 2010–11 (–₹394) also showed significant negative seasonal deviations.

To make these comparisons more meaningful across years, the Index of Seasonal Variation was calculated. This index expresses the seasonal variation as a percentage of the moving average. Further, it was normalized to adjust for different magnitudes, which helps identify how strong or weak the seasonal effect was in each year compared to others.

For example, the Normalized Seasonal Index in 2020–21 was –32.49, and in 2018–19 it was –28.40, both indicating very strong seasonal effects. In contrast, years like 2009–10 and 2008–09 had low seasonal variation values of ₹253.33 and ₹28.33, respectively, showing that prices during those years were relatively stable in seasonal terms.

The seasonal analysis shows that Black Gram prices are often affected by predictable short-term factors related to the agricultural calendar. Recognizing these patterns can help farmers and market players make better decisions regarding storage, timing of sales, and procurement.

Figure 2: Seasonal Variation in Black Gram Prices (2003–2023)

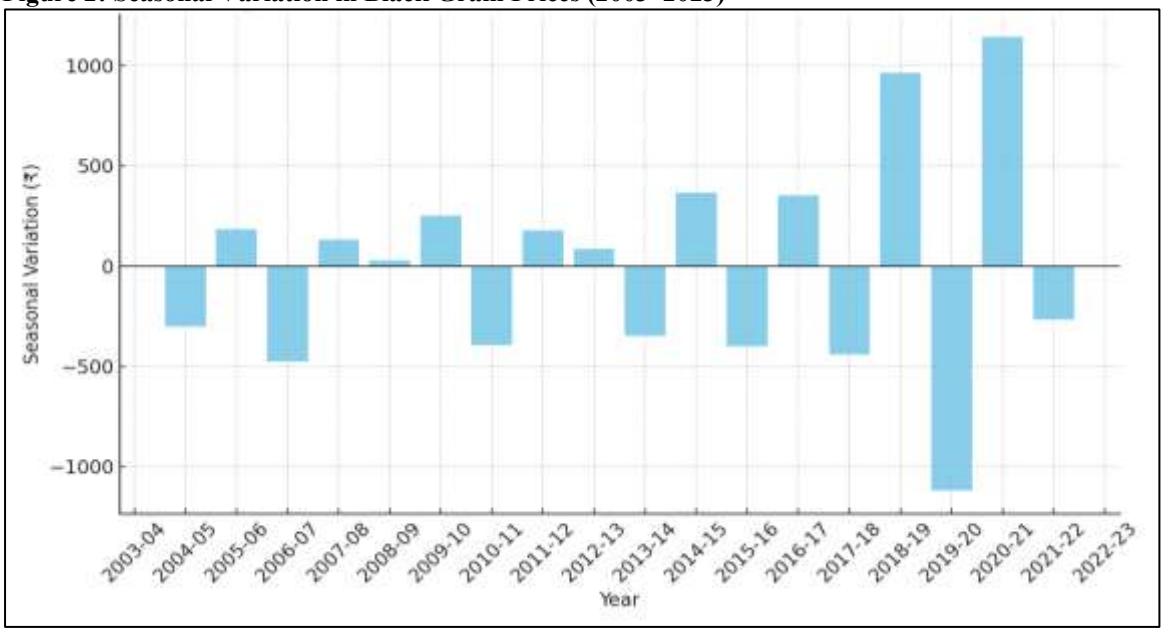

Figure 2: Seasonal Variation in Black Gram Prices (2003–2023)

Figure 2 presents the seasonal variation component calculated through a 3-year moving average. Positive values indicate prices above the seasonal average, while negative values indicate lower-than-average prices. The largest positive seasonal effects occurred in 2020–21 and 2018–19, while major negative effects were seen in 2019–20 and 2015–16.

3.4 Irregular Variation

Irregular variation refers to price changes that are unexpected and unpredictable. These variations are not part of the long-term trend or seasonal patterns. Instead, they occur due to sudden shocks, unusual events, or external influences such as extreme weather conditions, pest attacks, abrupt policy changes, transportation strikes, or global economic disruptions.

In this study, irregular variation was calculated by subtracting both the trend value and the seasonal variation from the actual price for each year. The formula used was:

Irregular Variation = Actual Price – Trend Price – Seasonal Variation

This helps separate the unexpected part of the price changes and their implications of the price, which cannot be explained by either trend or seasonal effects.

The results show that irregular price changes occurred frequently in the Black Gram market over the 20-year period. For instance, in 2006–07, the normalized irregular index was –42.18, which was the most extreme negative value recorded. This indicates a major downward shock in that year, possibly caused by overproduction, poor demand, or market oversupply.

In contrast, the year 2018–19 showed the highest positive irregular variation, with a normalized irregular index of +34.42. Similarly, 2020–21 had a high irregular index of +27.86. These results suggest that something unexpected caused prices to rise significantly above what was predicted by both trend and seasonal models. Possible reasons may include government intervention (like a sudden increase in minimum support prices (Ministry of Agriculture & Farmers Welfare, 2023)), supply shortages, or pandemic-related disruptions.

Other years such as 2004–05 and 2016–17 also experienced moderate positive irregularities, with normalized values of +13.62 and +15.97, respectively. This means that even in years with regular trends and seasonal behavior, sudden price changes can still occur due to market uncertainty.

On the lower end, 2010–11 and 2013–14 had negative irregular indices of –26.30 and –16.61, indicating weak market conditions that led to lower-than-expected prices even after accounting for trend and seasonality.

The presence of irregular variation in most years confirms that Black Gram prices are often influenced by random external factors beyond typical market behavior. These findings stress the importance of market intelligence, risk management, and policy buffers to deal with unexpected changes in price levels.

4. Social and Managerial Implications

4.1 Social Implications

The price pattern and sustainability of Black Gram has a direct impact on the lives of farmers, consumers, and rural communities.

1. **Farmer Income Stability**: In years when the price falls below the expected trend (such as 2022–23), farmers suffer income loss. Many small and marginal farmers depend solely on seasonal crops like Black Gram, and sharp price drops can push them into debt or distress.

2. **Food Security and Consumer Affordability**: During years with very high prices (such as 2018–19 or 2020–21), affordability becomes a concern for consumers, especially for poor households. Pulses are an important source of protein in Indian diets, and price surges affect nutritional security.
3. **Market Trust and Uncertainty:** Unpredictable irregular variations make it difficult for both producers and consumers to plan ahead. This affects trust in the agricultural marketing system (NABARD, 2021) and discourages investments in pulse cultivation.

4.2 Managerial Implications

The analysis provides important inputs for price-related decisions for stakeholders by policymakers, cooperatives, and agricultural planners.

1. **Price Forecasting and Policy Design:** The regression trend and cyclical patterns (Singh & Sharma, 2019) can be used to anticipate price changes and their implicationss and plan government interventions such as Minimum Support Price (MSP) announcements, subsidies, or buffer stock operations.
2. **Procurement and Distribution**: Government and private procurement agencies can use seasonal and irregular variation insights to plan storage, transport, and release of stock in the market. This will help in stabilizing prices during peak demand or crisis periods.
3. **Risk Management for Farmers**: Institutions such as farmer producer organizations (FPOs), cooperatives, and insurance companies can develop crop insurance schemes or price guarantees based on historical variation patterns. This will protect farmers from income loss in bad years.
4. **Inventory and Trade Decisions**: Traders and wholesalers can use these findings to decide when to buy, hold, or sell. Knowing the seasonal trends and past irregularities improves their bargaining power and stock planning.

5. Suggestions

Based on the detailed trend, cyclical, seasonal, and irregular analysis of Black Gram prices over the past two decades, several practical and policy-oriented suggestions are proposed. These recommendations aim to promote price stability, ensure income protection for farmers, and support better sustainable price management.

5.1 Introduce Price Stabilization Mechanisms

The study shows that Black Gram prices fluctuate significantly from year to year due to cyclical and irregular factors. A dedicated Price Stabilization Fund (PSF) should be strengthened at the national and state levels. This fund can be used to provide direct market intervention during price crashes (such as in 2022–23) or abnormal price rises (like in 2018–19), ensuring fair returns for farmers and affordability for consumers.

5.2 Promote Timely and Scientific Price Forecasting

The findings indicate that many price variations follow identifiable patterns. The government, agricultural universities, and cooperatives should develop seasonal and trend-based forecasting models using regression and time series methods. These forecasts can be shared regularly with farmers through mobile apps, Krishi Vigyan Kendras (KVKs), and agricultural extension programs to help them make informed decisions about sowing and selling.

5.3 Improve Warehousing and Storage Infrastructure

High seasonal and irregular variations suggest the need for better storage facilities. Farmers should be encouraged and supported to store their harvests during low-price seasons and sell during high-demand periods. Investments should be made in rural warehouses, cold storage units, and digital inventory systems through public-private partnerships (PPPs).

5.4 Strengthen Minimum Support Price (MSP) Procurement

In years of negative deviation from the trend (like 2019–20 or 2022–23), MSP-based procurement by government agencies becomes essential. Ensuring that MSP operations reach all pulse-growing regions and cover marginal farmers can prevent distress sales and stabilize rural incomes. The MSP should be dynamically adjusted based on seasonal and cyclical indicators derived from price analysis.

5.5 Expand Farmer Awareness and Training

The government should invest in awareness programs to train farmers on price trends, seasonal cycles, and marketing strategies. Farmer Producer Organizations (FPOs) can act as a bridge to disseminate this information, helping farmers decide the right time to plant, harvest, store, or sell their produce.

5.6 Encourage Crop Diversification

To reduce dependency on a single crop, especially during years with unstable Black Gram prices, farmers should be encouraged to adopt crop diversification. Agro-climatic-based advisories and incentives can promote the cultivation of complementary crops, spreading risk and ensuring income security.

5.7 Develop Smart Market Infrastructure

Finally, the integration of digital platforms like e-NAM (National Agricultural Market), mobile-based market information systems, and real-time pricing tools will empower farmers to access wider markets and better price discovery. These tools should incorporate historical price trend data to make them more effective and user-friendly.

6. CONCLUSION

This study presents a detailed analysis of Black Gram prices in India over a 20-year period, from 2003–04 to 2022–23. Using a combination of statistical tools like regression and moving average methods (FAO, 2021), and

index-based decomposition, the study successfully identified and interpreted the long-term trend, as well as short-term cyclical, seasonal, and irregular variations in market prices.

The results revealed a consistent upward trend in Black Gram prices, with an average annual increase of approximately ₹275.89. However, actual prices frequently deviated from this trend due to various predictable and unpredictable factors. Years like 2003–04, 2018–19, and 2020–21 witnessed strong positive deviations, while years such as 2019–20 and 2022–23 fell below expected levels.

Cyclical patterns showed medium-term economic influences, while seasonal effects reflected traditional agricultural cycles and demand fluctuations. Irregular variations highlighted the role of unexpected market disruptions such as policy shifts, weather events, or supply chain issues.

These findings underline the complex nature of agricultural price changes and their implications and the importance of timely and informed interventions. The analysis provides strong evidence for strengthening price forecasting systems, improving storage and procurement infrastructure, and designing support policies that are responsive to both expected trends and unforeseen shocks.

In conclusion, a balanced approach combining data-driven planning, farmer empowerment, and policy flexibility is essential to ensure stable Black Gram prices, protect farmer incomes, and support sustainable agricultural development in India.

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