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Economic Analysis of Agricultural Production and Inflation in India

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Abstract
The present study was undertaken to investigate the relationship between the inflation rate and agricultural production, as well as the association between Wholesale Price Index (WPI) inflation for food articles and agricultural output. The analysis was conducted using secondary data obtained from reliable sources, and the Engle and Granger (1987) two-step co-integration method was employed to examine the long-term relationship. The analysis shows that CPI inflation was stable until 2007, spiked sharply during the 2007–2010 global financial crisis, and then declined steadily until 2015. Since 2016, it has fluctuated moderately, with a notable peak around 7% in 2021. WPI inflation showed stability until 2007, spiked between 2008–2011, and fell sharply into deflation by 2015. After moderate recovery, it surged to 14% in 2021 before dropping significantly by 2023, reflecting overall volatility with a declining trend.
Keywords: Inflation, Engle-Granger, Co-integration, WPI

Introduction
Inflation refers to a sustained increase in the general price level of goods and services in an economy over time, which reduces the purchasing power of money. As prices rise, each unit of currency can buy fewer goods and services, leading to a decline in the real value of money as a medium of exchange and unit of account. Economists have defined and interpreted inflation in different ways. For instance, Coulborn described it as "too much money chasing too few goods," while Milton Friedman emphasized that "inflation is always and everywhere a monetary phenomenon." Several theories explain the causes of inflation. The Quantity Theory of Money attributes it to an increase in the supply of money, whereas Keynes linked it to the phenomenon of full employment. The Neo-Keynesian approach, particularly through the Phillips Curve, relates inflation to high demand for GDP and low unemployment. On the other hand, cost-push or supply-shock inflation arises from sudden increases in the prices of crude oil or raw materials. Agricultural production is a key determinant of price stability, food security, and inflation dynamics, particularly in agrarian economies such as India. The relationship between agricultural output and inflation has been extensively investigated across countries and time periods. Scholars have examined both the direct and indirect channels through which agricultural productivity influences consumer prices and overall macroeconomic stability. This section synthesizes theoretical and empirical findings to provide a foundation for the current study.
Classical economic theory suggests that agricultural production affects inflation primarily through supply-side mechanisms. Increased agricultural output expands food supply, reducing food prices and easing inflationary pressures, whereas production shortfalls due to weather, pests, or input constraints can raise prices (Chhibber, 1989). Keynesian perspectives add a demand-side dimension, noting that fluctuations in agricultural income influence aggregate demand and overall price levels (Datt & Ravallion, 1998). Structuralist economists emphasize that in developing countries, where food constitutes a large proportion of household consumption, fluctuations in agricultural output directly affect inflation through the food price channel. Monetarist theory, while asserting that inflation is mainly a monetary phenomenon, acknowledges that supply shocks particularly in agriculture can generate temporary deviations from long-term price stability (Friedman, 1968). Thus, analyzing the agriculture–inflation relationship requires integrating structural and monetary perspectives.
Empirical Studies at the Global Level: Global studies provide substantial evidence linking agricultural productivity to price stability. Baffes and Gardner (2003) found that growth in agricultural productivity reduces real food prices and moderates inflation in developing economies. Headey and Fan (2008) identified supply constraints, biofuel demand, and export restrictions as primary drivers of the 2007-2008 global food crisis. Abbott et al. (2011) similarly noted that agricultural supply shocks combined with rising energy prices were key determinants of global food price increases. In sub-Saharan Africa, Kpordzih and Pongo (2019) used co-integration and vector error correction models to demonstrate that agricultural productivity growth exerts a long-term deflationary effect on food inflation. In Latin America, Valdés and Foster (2010) showed that agricultural reforms and productivity gains significantly stabilized food prices and reduced inflationary pressures.
Evidence from India and Other Emerging Economies: In India, agricultural production, food prices, and inflation are closely interlinked due to the sector's dominance in employment and household consumption. Using a structural VAR model, Goyal and Tripathi (2012) found that negative agricultural supply shocks significantly increase inflation, particularly food inflation. Bhattacharya and Lodh (2017) highlighted the role of monsoon variability and output fluctuations as primary drivers of headline inflation. Reserve Bank of India reports (2015, 2019) emphasized that food inflation persistence is largely driven by production shortfalls in pulses, cereals, and perishable commodities. Co-integration analysis by Balakrishnan and Parameswaran (2018) further confirmed a long-run equilibrium relationship between agricultural GDP and food prices, indicating that production shocks have lasting impacts on inflation. Other emerging economies show comparable trends. In Bangladesh, Sarker and Rahman (2016) demonstrated that agricultural output growth reduces food price inflation in the long run. In Pakistan, Hussain and Malik (2011) identified agricultural supply shocks as contributors to inflation persistence. In China, Zhang et al. (2018) found that agricultural modernization has a long-term deflationary effect on food prices and overall consumer price indices.
Role of Supply Chains, Policy and Climate Variability: Recent research highlights the influence of structural and environmental factors on the agriculture-inflation nexus. Climate variability and extreme weather events significantly impact agricultural output and price volatility. Ahmed and Mukhwas (2020) found that rainfall anomalies and temperature shocks influence agricultural productivity and consumer prices in South Asia. Kumar et al. (2021) emphasized that agricultural inflation in India is increasingly driven by climate-induced production risks and inadequate storage and transportation infrastructure. Policy interventions also play a key role. Minimum support prices (MSP), procurement policies, and export bans can distort price transmission mechanisms. Gulati and Saini (2015) noted that while MSPs protect farmers' incomes, misalignment with productivity growth may increase inflation. Furthermore, improved logistics, cold storage facilities, and market integration help reduce price volatility (Dev & Sengupta, 2019).
Despite extensive literature, several gaps persist. Most studies focus on short-term dynamics rather than long-run equilibrium relationships. Few studies employ rigorous econometric methods such as co-integration and vector error correction models. Additionally, the heterogeneous impact of major crop groups such as cereals, pulses, wheat, and sugarcane—on inflation remains underexplored. This study addresses these gaps using co-integration analysis to investigate both short- and long-term dynamics between agricultural production, food prices, and inflation in India. The literature confirms a strong linkage between agricultural production and inflation via food price channels. Productivity growth stabilizes prices, while production shortfalls exacerbate inflation. However, the magnitude and persistence of these effects vary across regions, commodities, and policy environments. This study contributes to the literature by applying advanced econometric methods to analyze these dynamic relationships in India.
Measurement of Inflation: There are several inflationary measures followed by different countries. In India, Consumer Price Index and Wholesale Price Index are the two major indices for measuring inflation. WPI is measured on weekly basis and computed by the Office of the Economic Adviser, Ministry of Commerce and Industry, Government of India. The New Series with 2011-12 as the base year has 697 items and number of quotations is 8331 in the commodity basket of three broad categories viz. (1) Primary Articles (2) Fuel & power and (3) Manufactured Products. But the current base year for CPI is 2012 which may be the reason for increasing difference between CPI and WPI in recent times. CPI for Industrial Workers, CPI for Agricultural Labourers, CPI for Rural Labourers and CPI for Rural/Urban (Combined). The first two are compiled and released by the Labour Bureau, Ministry of Labour and Employment, the third by the Central Statistics Office, Ministry of Statistics and Programme Implementation. Recently, Consumer Food Price Index for all India Rural, Urban and Combined are also being released for December 2016. The GDP deflator is another measure of inflation, often regarded as more comprehensive than the CPI or WPI. In India, some analysts have advocated for using the GDP deflator as the primary measure of inflation. However, as noted by **Nadhanael & Pattnaik** (2010), recent quarterly figures for the GDP deflator provide limited additional information compared to the WPI and CPI. Therefore, this study will focus on illustrating how inflation, particularly food price inflation, has evolved in the country over the past decades, based on the WPI and CPI measures.
Methodology: The study utilized time series data on the CPI inflation rate (2014-2024) and the Index Number of Agricultural Production (2014-2024), with triennium-ending base years of 2007-08, sourced from the Ministry of Agriculture, Government of India. Monthly and annual data on CPI and WPI inflation rates were gathered from multiple sources, including the Handbook of Statistics on the Indian Economy (RBI), the Central Statistics Office (Ministry of Statistics and Programme Implementation, Government of India), and Press Information Bureau (Government of India), spanning various years and base years.
Analytical Procedure: The ADF test will be conducted to determine whether the time series has a unit root. This test is a valuable tool for assessing the stationary

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of time series data for accurate modelling and forecasting. Following this test, we get

$$\mathbf{Z_t = \beta Z_{t-1} + \varepsilon_t} \quad (1)$$

Where, $\mathbf{Z_t}$ = the value of the time series variable, $\boldsymbol{\alpha}$ = constant term, $\boldsymbol{\varepsilon_t}$ = Error term
Substitute Z_{t-1} on both side in equation (1)

$$Z_t - Z_{t-1} = \beta Z_{t-1} - Z_{t-1} + \varepsilon_t$$
$$\Delta Z_t = (\beta - 1) Z_{t-1} + \varepsilon_t$$
$$\Delta Z_t = \gamma Z_{t-1} + \varepsilon_t \quad (2)$$

The equation (2) is known as Dickey-Fuller equation and the equation has no trend & no constant.

$$\Delta Z_t = \alpha + \gamma Z_{t-1} + \varepsilon_t \quad (3)$$

The equation (3) has constant and no trend.

$$\Delta Z_t = \alpha + \beta t + \gamma Z_{t-1} + \varepsilon_t \quad (4)$$

The equation (4) has constant and time trend.
To increase the fitness of the series to add dependent variable Δt as an independent variable and the equation (4) becomes

$$\Delta Z_t = \alpha + \beta t + \gamma Z_{t-1} + \sum_{i=1}^{n} \phi \Delta Z_{t-i} + \varepsilon_t \quad (5)$$

The equation (5) is known as Augmented Dickey-Fuller equation. The Augmented Dickey-Fuller (ADF) test is based on the following regression equation.

$$\text{For} \begin{cases} \beta = 1 \Rightarrow \text{the process is not stationary} \\ \beta < 1 \Rightarrow \text{the process is not stationary} \\ \beta > 1 \Rightarrow \text{the process is called explosive} \\ \text{and increases over time} \end{cases}$$

Each Augmented Dickey-Fuller test uses the following hypotheses:
Null hypothesis, H_0: $\gamma = 1$ (equivalent to $\beta = 1$ and time series will be Non − stationary)
Alternative hypothesis, H_1: $\gamma < 1$ ($equivalent\ to\ \beta < 1\ and\ time\ series\ will\ be\ stationary$)

The null hypothesis, which, show the presence of a unit root (non-stationary), will be tested against the alternative hypothesis of no unit root (stationary) at both the level and differenced series. If the data is non-stationary, it is possible that a linear combination of integrated variables is stationary, meaning the variables are co-integrated. If the test statistic is less than the critical value or if the p-value is less than a pre-specified significance level (e.g. 0.05), then the null hypothesis is rejected and the time series is considered stationary. If the test statistic is greater than the critical value, the null hypothesis cannot be rejected, and the time series is considered non-stationary. To examine the relationship between the CPI-combined inflation rate and agricultural production, as well as the relationship between the WPI-Food Articles inflation rate and agricultural production, the Engle & Granger (1987) two-step co-integration test will be employed. Co-integration is an econometric technique used to test for a long-run relationship between non-stationary time series variables. If two or more series are individually non-stationary but a linear combination of them is stationary, then the series are said to be co-integrated. If both time series are integrated to the same order, it is possible to estimate the following co-integration regression.

$$CPI_t = x_{11} + y_{11} AP_t + \lambda_t \quad (6)$$
$$AP_t = x_{21} + y_{21} CPPI_t + \delta_t \quad (7)$$
$$WPI - FA_t = x_{31} + y_{31} AP_t + \sigma_t \quad (8)$$
$$AP_t = x_{41} + y_{41} WPI - FA_t + \xi_t \quad (9)$$

Where $CPI_t = Inflation\ rate, AP_t = Index\ of\ Agricultural\ Production,$
$WPI - FA_t = Wholesale\ Price\ Index\ of\ Food\ Article\ at\ time\ t,$
$\lambda_t, \delta_t, \sigma_t\ and\ \xi_t\ are\ error\ terms.$

Results and discussion

Trends of Inflation in India

Inflation has been a persistent issue in India for a long time. India's inflation dynamics have undergone significant changes over the past few decades, driven by various internal and external factors.

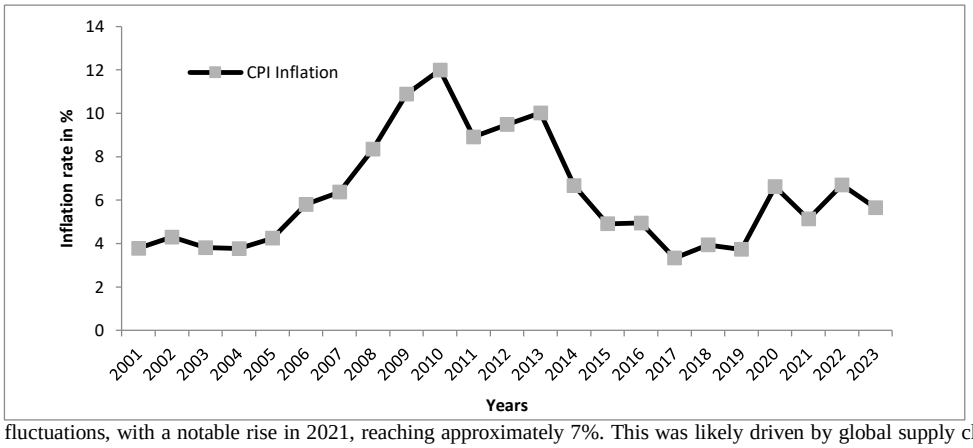

Fig. 1: Trend of consumer price index inflation rate of India for the period of 2001-2023

The above graph illustrates the trend in the Consumer Price Index (CPI) inflation rate over the period from 2001 to 2023. The data reveal several key phases of inflation behavior across these years. From 2001 to 2007, the CPI inflation rate remained relatively stable, fluctuating between 3% and 6%. However, a significant inflationary spike is observed between 2007 and 2010, where the inflation rate peaked at approximately 12% in 2010. This period coincides with the global financial crisis, which contributed to rising inflationary pressures. Post-2010, the inflation rate exhibited a downward trend, falling below 4% by 2015. From 2016 onwards, the inflation rate showed moderate fluctuations, with a notable rise in 2021, reaching approximately 7%. This was likely driven by global supply chain disruptions and economic recovery measures post-pandemic. As of 2023, the inflation rate appears to have stabilized around 6%. This graph provides a clear visual representation of how external global economic factors, such as the 2008 financial crisis and the COVID-19 pandemic, impacted inflation trends over the past two decades.

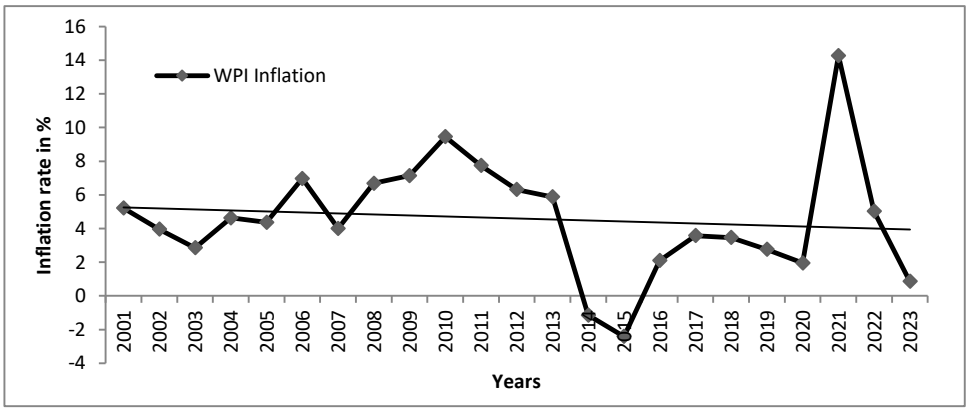

Fig. 2: Trend of Whole Price Index inflation rate of India for the period of 2001-2023

The graph shows the wholesale price index (WPI) inflation rate from 2001 to 2023. Between 2001 and 2007, WPI inflation remained relatively stable between 3% and 7%. A significant increase occurred from 2008 to 2011, peaking at 9% in 2011. From 2013 to 2015, a sharp deflationary period is visible, with inflation dropping to around -2% in 2015. Inflation recovered slightly between 2016 & 2020. In 2021, WPI inflation spiked to 14%, likely due to post-pandemic disruptions. By 2023, inflation dropped significantly, signaling a sharp correction in wholesale prices. The overall trend suggests volatile but declining WPI inflation over the years.

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Food Inflation

Food inflation is the persistent rise in food commodity prices, driven by increasing production, labor, and transportation costs. Population growth adds demand pressure, while climate change disrupts agricultural productivity. Hoarding and speculation in food markets can also inflate prices, and land degradation reduces available farmland, further limiting supply. These factors collectively contribute to rising food prices.

Table 1: Wholesale price index inflation of all commodities and different commodity groups

Years	All Commodities	Food Articles	Non-Food Articles	Primary Articles	Fuel & Power	Manufactured Products
Jan-23	4.80	2.67	4.70	4.06	15.00	3.06
Feb-23	3.85	3.81	0.00	3.64	13.96	1.94
Mar-23	1.34	5.48	-4.63	2.40	8.96	-0.77
Apr-23	-0.92	3.54	-6.59	1.60	0.93	-2.42
May-23	-3.61	1.63	-9.51	-1.90	-9.17	-3.03
Jun-23	-4.18	1.32	-9.66	-2.98	-12.51	-2.78
Jul-23	-1.23	15.09	-5.76	8.24	-12.73	-2.58
Aug-23	-0.46	11.43	-6.80	6.73	-6.34	-2.30
Sep-23	-0.07	3.79	-2.14	4.38	-3.35	-1.27
Oct-23	-0.26	3.17	-1.14	2.26	-1.58	-1.06
Nov-23	0.39	8.84	-2.96	5.16	-4.05	-0.78
Dec-23	0.86	9.32	-5.20	5.73	-1.39	-0.78
Jan-24	0.33	6.91	-6.39	4.07	-0.45	-1.20
Feb-24	0.20	7.07	-6.52	4.55	-1.71	-1.27
Mar-24	0.26	7.05	-4.25	4.57	-2.75	-0.85
Apr-24	1.19	8.07	-4.77	5.23	-0.85	-0.14
May-24	2.74	9.93	-3.87	7.42	1.01	1.00
Jun-24	3.43	11.14	-1.01	9.20	0.48	1.50

Inflation trends across commodity categories. "All Commodities" inflation declined sharply in early 2023, reaching -4.18% in June, but recovered to 3.43% by mid-2024. "Food Articles" exhibited volatility, peaking at 15.09% in July 2023, while "Non-Food Articles" consistently faced negative inflation. "Fuel & Power" experienced significant fluctuations, dropping from 15% in January 2023 to -12.73% by mid-2023, before stabilizing. "Manufactured Products" showed deflation throughout 2023, turning positive by mid-2024. Overall, inflation trends stabilized by mid-2024, driven primarily by food and primary articles.

Table 2: ADF test for a unit root on the level series of the Variable CPI Inflation, WPI-FA Inflation, Index number of agricultural production

Null Hypothesis: **CPI Inflation** has a unit root Exogenous: **None** Lag Length: 0 (Automatic –based on SIC, maxlag = 4)			
		t- Statistic	Probability
Augmented Dickey-Fuller test statistic		-0.375976	0.5371
Test critical values:	1% level 5% level	-2.674290 -1.957204	
Null Hypothesis: CPI Inflation has a unit root Exogenous: **Constant** Lag Length: 4 (Automatic –based on SIC, maxlag = 4)			
		t- Statistic	Probability
Augmented Dickey-Fuller test statistic		-3.817300	0.0108
Test critical values:	1% level 5% level	-3.857386 -3.040391	
Null Hypothesis: CPI Inflation has a unit root Exogenous: **Constant, Linear Trend** Lag Length: 4 (Automatic –based on SIC, maxlag = 4)			
		t- Statistic	Probability
Augmented Dickey-Fuller test statistic		-4.079471	0.0248
Test critical values:	1% level 5% level	-4.571559 -3.690814	

Results have been obtained using the data from Economic Survey, Government of India, 2022-23, and Office of the economic adviser, Ministry of commerce & industry, Government of India, 2001-02 to 2022-23.

Null Hypothesis: **WPI-FA Inflation** has a unit root Exogenous: **None** Lag Length: 0 (Automatic –based on SIC, maxlag = 4)			
		t- Statistic	Probability
Augmented Dickey-Fuller test statistic		-1.278159	0.1792
Test critical values:	1% level 5% level	-2.674290 -1.957204	
Null Hypothesis: WPI-FA Inflation has a unit root Exogenous: **Constant** Lag Length: 0 (Automatic –based on SIC, maxlag = 4)			
		t- Statistic	Probability
Augmented Dickey-Fuller test statistic		-2.810821	0.0730
Test critical values:	1% level 5% level	-3.769597 -3.004861	
Null Hypothesis: WPI-FA Inflation has a unit root Exogenous: **Constant, Linear Trend** Lag Length: 0 (Automatic –based on SIC, maxlag = 4)			
		t- Statistic	Probability
Augmented Dickey-Fuller test statistic		-2.822234	0.2046
Test critical values:	1% level 5% level	-4.440739 -3.254671	

Results have been obtained using the data from Economic Survey, Government of India, 2022-23, and Office of the economic adviser, Ministry of commerce & industry, Government of India, 2001-02 to 2022-23.

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Table 3: ADF test for a unit root on the first differenced series of the Variable CPI Inflation, WPI-FA Inflation, Index number of agricultural production			
Null Hypothesis: D **(**CPI Inflation**)** has a unit root Exogenous: **None** Lag Length: 0 (Automatic –based on SIC, maxlag = 4)			
		t- Statistic	Probability
Augmented Dickey-Fuller test statistic		-4.488234	0.0001
Test critical values:	1% level 5% level	-2.679735 -1.958088	
Null Hypothesis: D (CPI Inflation) has a unit root Exogenous: **Constant** Lag Length: 0 (Automatic –based on SIC, maxlag = 4)			
		t- Statistic	Probability
Augmented Dickey-Fuller test statistic		-4.377158	0.0028
Test critical values:	1% level 5% level	-3.788030 -3.012363	
Null Hypothesis: D (CPI Inflation) has a unit root Exogenous: **Constant, Linear Trend** Lag Length: 0 (Automatic –based on SIC, maxlag = 4)			
		t- Statistic	Probability
Augmented Dickey-Fuller test statistic		-4.350347	0.0127
Test critical values:	1% level 5% level	-4.467895 -3.644963	

Results have been obtained using the data from Economic Survey, Government of India, 2022-23, and Office of the economic adviser, Ministry of commerce & industry, Government of India, 2001-02 to 2022-23.

Null Hypothesis: D (**WPI-FA Inflation)** has a unit root Exogenous: **None** Lag Length: 1 (Automatic –based on SIC, maxlag = 4)			
		t- Statistic	Probability
Augmented Dickey-Fuller test statistic		-5.732750	0.0000
Test critical values:	1% level 5% level	-2.685718 -1.959071	
Null Hypothesis: D (WPI-FA Inflation) has a unit root Exogenous: **Constant** Lag Length: 1 (Automatic –based on SIC, maxlag = 4)			
		t- Statistic	Probability
Augmented Dickey-Fuller test statistic		-5.575537	0.0002
Test critical values:	1% level 5% level	-3.808546 -3.020686	
Null Hypothesis: D (WPI-FA Inflation) has a unit root Exogenous: **Constant, Linear Trend** Lag Length: 1 (Automatic –based on SIC, maxlag = 4)			
		t- Statistic	Probability
Augmented Dickey-Fuller test statistic		-5.602556	0.0011
Test critical values:	1% level 5% level	-4.498307 -3.658446	

Results have been obtained using the data from Economic Survey, Government of India, 2022-23, and Office of the economic adviser, Ministry of commerce & industry, Government of India, 2001-02 to 2022-23.

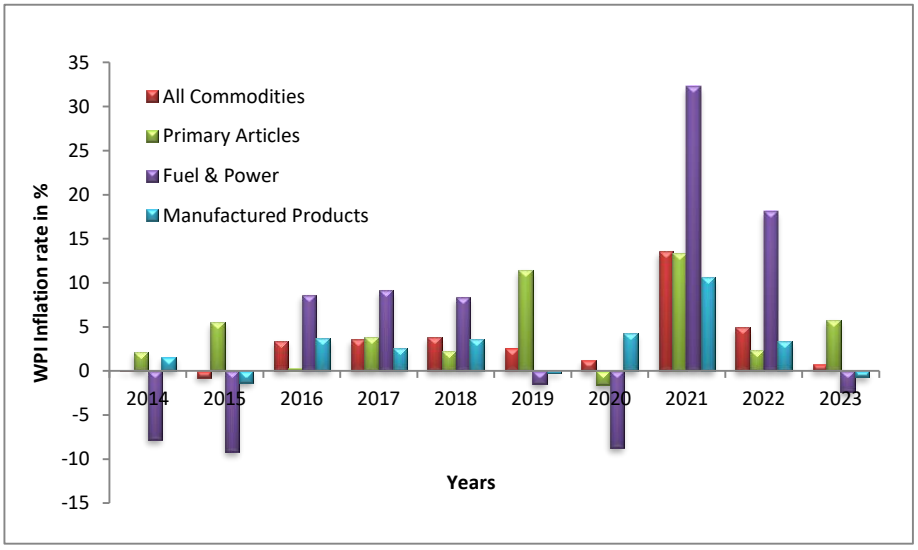

Fig. 3: Wholesale price index inflation of all commodities and different commodity groups

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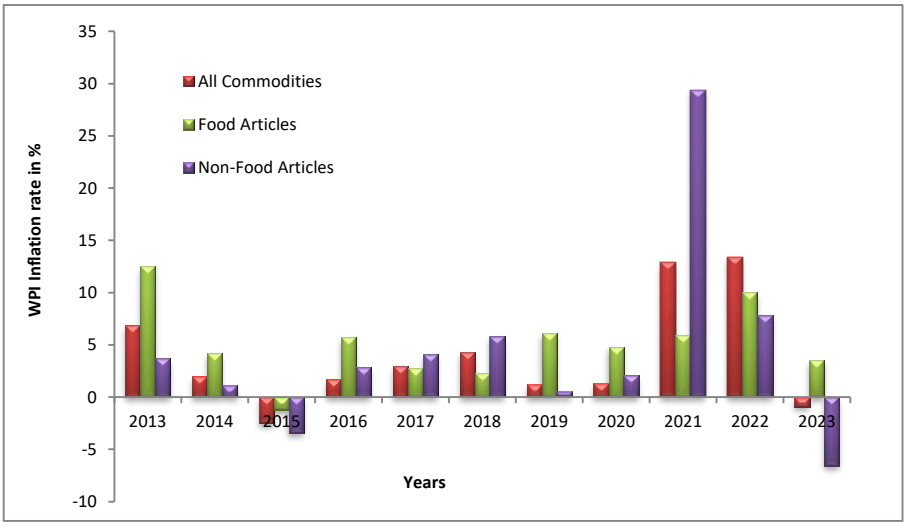

Fig. 4: WPI inflation rate of all the commodities and food article

Conclusions

The empirical result of the study indicates meaningful long run relationship between trends in agricultural production on both headline and food inflation. CPI and WPI inflation were stable until 2007, spiked during 2008–2011, declined to near 4% (CPI) and -2% (WPI) by 2015, and after a sharp surge in 2021, both corrected by 2023. Commodity-wise, "All Commodities" dropped to -4.18% (June 2023) but recovered to 3.43% by mid-2024; "Food Articles" peaked at 15.09% (July 2023); "Non-Food Articles" stayed negative; "Fuel & Power" swung from 15% (Jan 2023) to -12.73% (mid-2023) before stabilizing; and "Manufactured Products" showed deflation in 2023, turning positive by mid-2024. Overall, inflation trends were volatile but stabilized by mid-2024, driven mainly by food and primary articles.

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