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Growth and Fluctuations of Yields of Rice, Wheat, Pulses and Oil Seeds in India, West Bengal and Odisha: 1970-71 to 2019-20

Kuntal Dutta[1], Dipankar Pradhan[2], and Debasish Mondal[3]

[1] Research Scholar, Department of Economics, Vidyasagar University, Midnapore, West Bengal, India
[2] Assistant Professor, Faculty of Management and Commerce, The ICFAI University, Tripura, India
[3] Professor, Department of Economics, Vidyasagar University, West Bengal, India

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ABSTRACT- The agriculture sector is fundamental to achieving stable growth in a developing country like India, where consistent yields of major crops with minimal fluctuations contribute significantly to economic stability and food security. This study analyses the growth and fluctuations in the yields of four key crops—rice, wheat, pulses, and oilseeds—across India and the states of West Bengal and Odisha from 1970-71 to 2019-20. We estimate growth rates using the Exponential Annual Growth Rate (EAGR) and Compound Annual Growth Rate (CAGR) and assess yield fluctuations through multiple measures, including the RSS-based measure, the Cuddy-Della Valle Index [3], Coppock's fluctuation index, and a Modified Coppock's fluctuation index, to capture diverse aspects of yield variability. Our results indicate significant growth rates in the yields of all four crops for both India and West Bengal. In Odisha, rice and oilseeds show significant growth rates, while wheat and pulses do not. Distinct patterns of yield fluctuation are observed for each crop across India, West Bengal, and Odisha, underscoring the varying regional challenges in agricultural production. These findings can inform targeted policies to promote stable agricultural productivity and, consequently, economic growth.

KEYWORDS- Agricultural Growth, Yield Fluctuations, Exponential & Compound Growth Rates, Cuddy-Della Valle & Coppock's Index, Regional Crop Performance

JEL Classification: O4, Q1

I. INTRODUCTION

Agriculture is a vital part of the Indian economy. In India, about 70 percent of the population depends on agriculture, either directly or indirectly, for their livelihood. Thus, agricultural development is key to the overall development of the country and its states. Indian agriculture is highly dependent on rainfall, and India has made earnest efforts to increase production by applying science and technology. Fluctuations in agricultural output often arise due to economic cycles in open markets and periodic behaviours, as well as sudden unforeseen events like natural calamities and wars. Growth and fluctuation in agricultural output can be explained by an autoregressive model of some order. Food grain yields, as well as the overall production of food grains, are the primary determinants of a country's ability to meet the basic food requirements of its citizens. For a densely populated country like India, analysing food grain growth trajectories under different policy regimes is crucial for informed policy-making. This study aims to examine the yield trends of rice, wheat, pulses, and oilseeds in India and the states of West Bengal and Odisha from 1970-71 to 2019-20.

A. Rice

Rice is a staple food crop in India, providing a livelihood to millions. India is the second-largest rice producer globally, contributing about 43 million hectares, or 22 percent, of the world's rice production[13]. Rice thrives in hot and humid climates and can be grown in various forms, including Aush, Aman, and Boro.

B. Wheat

Wheat is the second most important crop in India after rice. It is a principal source of calories, especially in the northern and northwestern regions of the country. Globally, India ranks fourth in wheat production, following Russia, the USA, and China, accounting for 8.7 percent of world production[13].

C. Pulses

Pulses are an essential protein source for vegetarians and can be grown in diverse climatic conditions. They are profitable for farmers and contribute to both agricultural and environmental sustainability. India is the largest producer of pulses globally, accounting for 25 percent of global production[13]. Currently, about 16.47 million tonnes of pulses are produced on 25.26 million hectares, with an average productivity of 625 kg/ha[12].

D. Oilseeds

India is also a major producer of oilseeds, covering about 20 percent of the global area and contributing 10 percent of global production. Oilseeds occupy an important place in the Indian agricultural economy, ranking fourth in terms of significance (NABARD, 2014).

II. REVIEW OF LITERATURE

Coppock [1] has measured the year-to-year fluctuation in a time series by the formula, $F_{COPPOCK} = \text{Exp}\left(\text{S.D.}\left(\ln\left(\frac{Y_{t+1}}{Y_t}\right)\right)\right)$. Cuddy and Della Valle[3] expand to estimate the uncertainty in time series data that is identified by trend and the admirable equation is $CDVI = CV \times \sqrt{(1-\bar{R}^2)}$. Ray [2] noted that production environments under human control may achieve higher growth and stability. Chand and Raju[5] pointed out that, in large states like Andhra Pradesh, the uncertainty measured at the state level may vary significantly from that observed at more localized levels. The Cuddy-Della Valle fluctuation (CDVI) and Coppock fluctuation index are not directly comparable; Mondal and Mondal Saha[6] discussed theoretical adjustments to address the incomparability between F-RSS and F-Coppock indices. Chand and Raju [7] observed that yield variability in both food and non-food grains was lower in the early stages of the Green Revolution compared to the pre-Green Revolution period, with yield fluctuations in cereals and pulses decreasing over time. In a later study, Chand et al. [8] found that the area of food grains under irrigation in all Indian states except Tamil Nadu was below 40 percent, compared to the national average of 44 percent. Yadav and Kalola[9] examined the growth in area, production, and productivity of sorghum and bajra in the Middle Gujarat Zone using various models, including linear, nonlinear, time series (ARIMA), and polynomial models. Tewari et al. [10] analysed the growth and fluctuations in wheat production in Uttar Pradesh using the compound annual growth rate, Cuddy-Della Valle Index, and decomposition analysis. Anjum and Madhulika [13] studied the growth and fluctuation patterns in major Indian crops using both the Cuddy-Della Valle Index (1978) and Coppock's Fluctuation index[1], identifying different fluctuation patterns in area, production, and productivity. Kumar et al. [11] conducted trend and fluctuation analyses in area, production, and productivity, while Ahmad et al.[12] performed similar analyses on the area and production of pulses using compound annual growth rates and the Cuddy-Della Valle Index.

III. DATA SOURCES AND METHODOLOGY

A. Data Sources

In our study, we use secondary data from the RBI Handbook of Statistics. Yield data for the state of West Bengal was collected from the Statistical Abstracts published by the Bureau of Applied Economics and Statistics (BAES). Yield data for Odisha was sourced from the Odisha Agriculture Statistics 2020.

B. Growth

We analyse the trends in the yields of rice, wheat, pulses, and oilseeds in India, West Bengal, and Odisha using the Exponential Annual Growth Rate (EAGR) and Compound Annual Growth Rate (CAGR). A semi-log-linear trend regression model is typically used to estimate the simple growth of a time series variable. It can be expressed as: $LnY_t = a + bt + e_t$

Where, 'b' stands for the constant rate of exponential growth, 'Ln' stands for natural logarithm, 'Y_t' is the dependent variable, 't' stands for time and 'e_t' is the random error term.

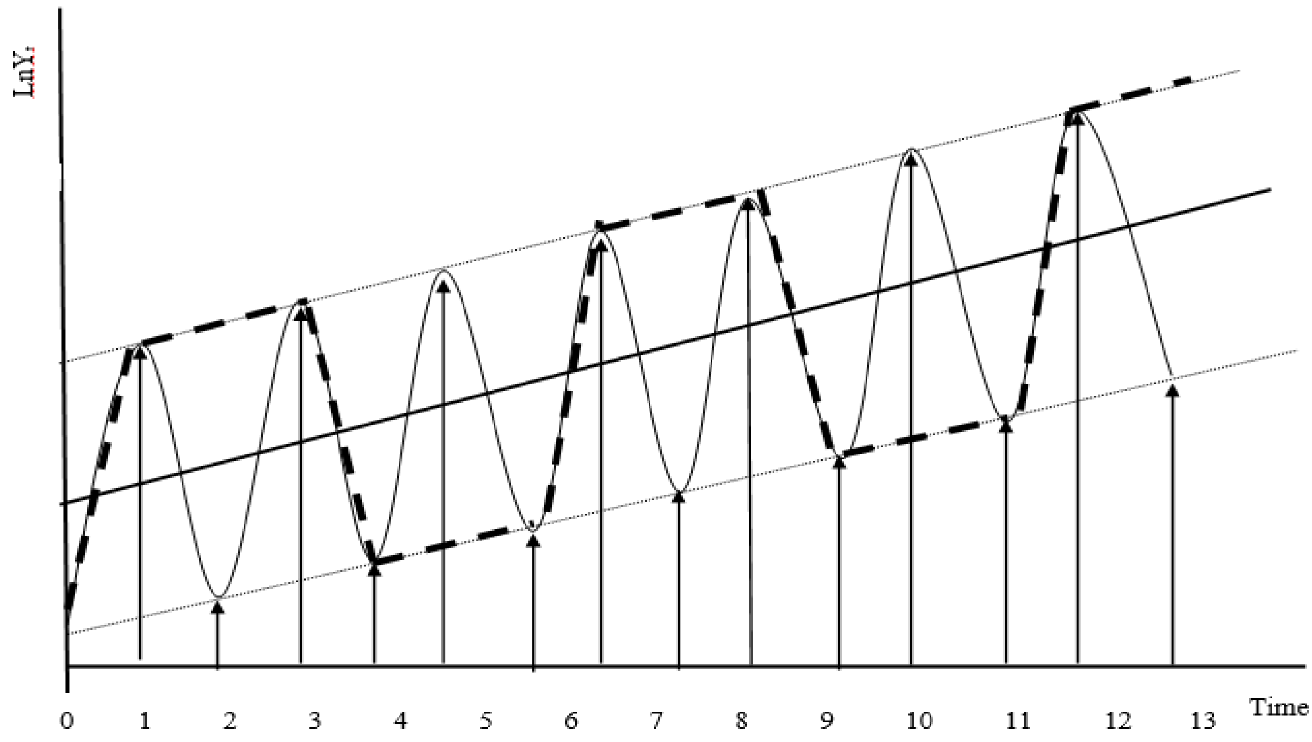
On the other hand, we estimate the compound annual growth rate using: CAGR = [exp(b)-1]

C. Fluctuation

The fluctuation in a time series variable can be measured by a number of methods like the Coefficient of Variation (CV), Dispersion, Cuddy Della Valle Index (CDI), Coppock fluctuation index etc. Fluctuation can be perceived as the average deviation of the data with reference to a fitted model or trend. The RSS based measure of fluctuation captures a relative average fluctuation of the data with reference to the logarithmic trend. It can be expressed as: $F_{RSS} = \sqrt{\frac{1}{T}\sum_{t=1}^{T} e_t^2} \Big/ \overline{\ln Y_t}$, where e_t captures the deviation of observed values from the estimated values of the fitted model or trend. The numerator is the square root of the average residual sum of squares (RSS) while the denominator is the average value of LnY_t. It is normally expressed in percentage terms. It is a measure similar to the coefficient of variation, but in this case, the standard deviation of the residuals is expressed as a proportion of the mean value of LnY_t rather than the mean value of the residuals. The Cuddy-Della Valle Index first de-trends the given series, providing a clear indication of fluctuation. Cuddy-Della Valle [3] and Della Valle [4] use a measure of fluctuation in the form of $CV(LnY_t)\sqrt{1-\bar{R}^2}$, arguing that $CV(LnY_t)$ quantifies the variation in LnY_t. A portion of this variation is attributed to the trend, with the proportion of the trend accurately represented by $\bar{R}^2$, while the remainder reflects fluctuation.

D. Coppock Fluctuation Index

To calculate year-to-year fluctuation, we use the Coppock Fluctuation Index (Coppock[1]) with the following formula: $F_{Coppock} = EXP\left(S.D.\left(Ln\left(\frac{Y_{t+1}}{Y_t}\right)\right)\right)$. If the series Y_t experiences constant growth, then the ratio between Y_{t+1} and Y_t, or the differences between $Ln(Y_{t+1})$ and LnY_t, become constant. As a result, the standard deviation (S.D.) of these differences becomes zero, and the antilog of the standard deviation equals one [2]. However, these two measures are not directly comparable. To explain why, we use the following figure to illustrate the conceptual difference between the RSS-based measure of fluctuation and Coppock's measure of fluctuation.



(Source: Mondal and Mondal Saha [6])

Figure 1: Conceptual difference between RSS based measure of fluctuation and Coppock's measure of fluctuation

Figure 1 depicts two time series: one characterized by year-to-year fluctuations, represented by a solid curve with short cycles (completing a full cycle in two years), and the other by a dashed curve with longer cycles (completing a full cycle in six years). The bold solid line in the middle represents the growth path around which the fluctuations occur. When fluctuation is analysed in terms of deviations from this long-run growth path, the RSS-based measure is relevant, and, according to this measure, the fluctuation is the same for both curves. However, when fluctuation is assessed in terms of year-to-year variations and their deviations from the growth path's implied year-to-year fluctuations, Coppock's measure becomes more applicable. Using this measure, the fluctuation for the curve with longer cycles will be smaller than that for the one with shorter cycles. This is because, in the former, the year-to-year fluctuations from t=1 to t=2, t=2 to t=3, and so on, are similar to those predicted by the growth path, even though the series shows substantial deviations from the trend path (within the indicated bands) during those years. The difference in Coppock's measure of fluctuation between the two paths helps identify and quantify the average length of the cycles experienced by the series. To make them comparable Coppock's measure can be modified through rationalization of $S.D(Ln(\frac{Y_{t+1}}{Y_t}))$ by $2(\overline{LnY_t})$. The adjusted Coppock measure is thus given by $F'_{Coppock} = (SD\,(Ln(\frac{Y_{t+1}}{Y_t})))/(2(\overline{LnY_t})$. Now F_{RSS} and $F'_{Coppock}$ are comparable and the average length of a full cycle present in the data can be estimated by $2(F_{RSS}/F'_{Coppock})^2$. A detailed theoretical discussion of this adjustment to resolve the incomparability between these two major fluctuation measures can be found in Mondal and Mondal Saha[6].

IV. RESULTS AND FINDINGS

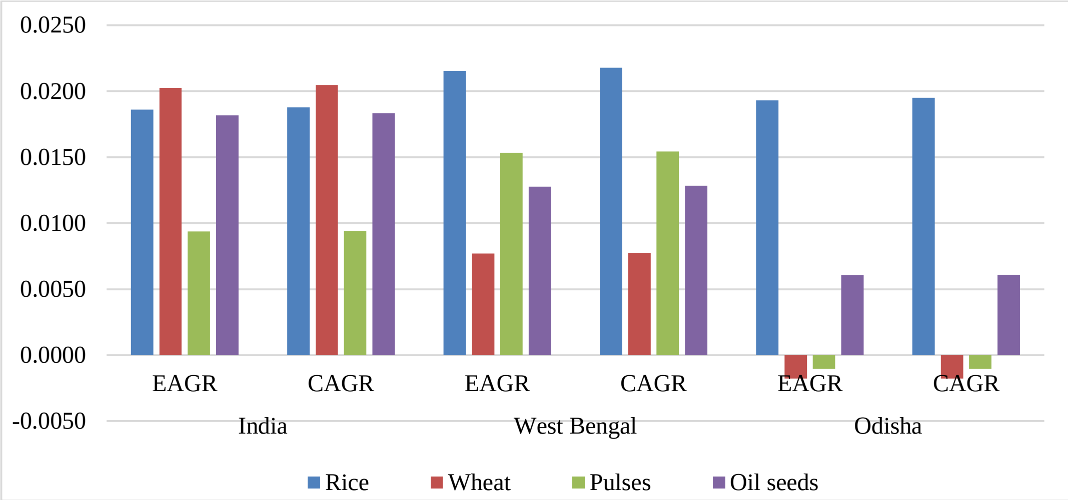
A. Growth Trend Analysis of Rice, Wheat, pulses and Oil seeds in India, West Bengal and Odisha

The results of the growth trend analysis of the yields of rice, wheat, pulses, and oilseeds in India, West Bengal, and Odisha are calculated using the Exponential Annual Growth Rate (EAGR) and Compound Annual Growth Rate (CAGR), as shown in Table 1.

Table 1: EAGR and CAGR in yield of Rice, Wheat, Pulses and Oilseeds in India, West Bengal and Odisha: 1970-71 to 2019-20

Crops	India			West Bengal			Odisha		
	EAGR	CAGR	P-Value	EAGR	CAGR	P-Value	EAGR	CAGR	P-Value
Rice	0.0186	0.0188	3.9E-32	0.0215	0.0218	7.4E-27	0.0193	0.0195	1.6E-14
Wheat	0.0203	0.0205	8.9E-29	0.0077	0.0077	6.3E-09	-0.0018	-0.0018	0.1374
Pulses	0.0094	0.0094	4.1E-16	0.0153	0.0154	3.7E-15	-0.0011	-0.0011	0.4444
Oil seeds	0.0182	0.0183	4.1E-24	0.0128	0.0128	0.0017	0.0061	0.0061	0.0002

(Source: author's own calculation based on secondary data)



(Source: author's own calculation based on secondary data)

Figure 2: EAGR and CAGR of yield of Rice, Wheat, Pulses and Oil seeds in India, West Bengal and Odisha: 1970-71 to 2019-20

Table 1 and Figure 2 show the Exponential Annual Growth Rate (EAGR) and Compound Annual Growth Rate (CAGR) of the yields of rice, wheat, pulses, and oilseeds in India, West Bengal, and Odisha. The EAGR of rice yield in India is 1.86%, and the CAGR is 1.88%, with a p-value of 3.9E-32, which is highly significant. Similarly, in West Bengal and Odisha, the EAGR is 2.15% and 1.93%, and the CAGR is 2.18% and 1.95%, with p-values of 7.4E-27 and 1.6E-14, respectively, both of which are highly significant. Comparing the rice yields in West Bengal and Odisha, West Bengal performs slightly better than Odisha. The EAGR and CAGR of wheat yield in India are 2.03% and 2.05%, with a p-value of 8.9E-29, which is highly significant. In West Bengal, both the EAGR and CAGR of wheat yield are 0.77%, with a p-value of 6.3E-09, which is highly significant. However, both the EAGR and CAGR of wheat in Odisha are negative and insignificant. The EAGR and CAGR of pulses yield in India are both 0.94%, with a p-value of 4.1E-16, which is highly significant. In West Bengal, the EAGR and CAGR are 1.53% and 1.54%, with a p-value of 3.7E-15, which is also highly significant. However, in Odisha, both the EAGR and CAGR are negative and insignificant. The EAGR and CAGR of oilseeds yield in India are 1.82% and 1.83%, with a p-value of 4.1E-24, which is highly significant. In West Bengal, both the EAGR and CAGR of oilseeds yield are 1.28%, with a p-value of 0.0017, which is significant. In Odisha, both the EAGR and CAGR are 0.61%, with a p-value of 0.0002, which is significant.

B. Fluctuation Analysis of Rice, Wheat, Pulses and Oil seeds in India, West Bengal and Odisha

Fluctuation of yield of Rice, Wheat, Pulses and Oil seeds in India, West Bengal and Odisha for the study periods is examine by using F_{RSS} and Cuddy-Della Valle fluctuation index (CDVI) is shown in Table 2.

Table 2: F_{RSS} and CDVI of yield of Rice, Wheat, Pulses and Oilseeds in India, West Bengal and Odisha: 1970-71 to 2019-20

Crops	**India**		**West Bengal**		**Odisha**	
	F_{RSS}	**CDVI**	F_{RSS}	**CDVI**	F_{RSS}	**CDVI**
Rice	0.0086	0.0087	0.0128	0.0130	0.0249	0.0252
Wheat	0.0107	0.0108	0.0142	0.0143	0.0158	0.0159
Pulses	0.0122	0.0123	0.0209	0.0211	0.0221	0.0223
Oil seeds	0.0142	0.0143	0.0565	0.0570	0.0231	0.0234

(Source: author's own calculation based on secondary data)

Table 2 shows the fluctuation in the yields of rice, wheat, pulses, and oilseeds in India, West Bengal, and Odisha. Upon observing the table, we find very little difference between the F-RSS and CDVI for all the crops studied, both for India and its two states, West Bengal and Odisha. Oilseeds in West Bengal exhibit the highest fluctuation, with F-RSS and CDVI values of 0.0565 and 0.0570, respectively. The second highest fluctuation in yield is observed for rice in Odisha, with F-RSS and CDVI values of 0.0249 and 0.0252, respectively. The lowest fluctuation in rice yield is found in India, with F-RSS and CDVI values of 0.0086 and 0.0087, respectively.

C. Coppock's Fluctuation Index of yield of Rice, wheat, pulses and Oil seeds in India, West Bengal and Odisha

To calculate the F-RSS and Cuddy-Della Valle Index for the yields of rice, wheat, pulses, and oilseeds in India, West Bengal, and Odisha, we first compute these indices, followed by the calculation of Coppock's Fluctuation Index.

Table 3: Coppock's Fluctuation index of yield of Rice, Wheat, Pulses and Oil seeds in India, West Bengal and Odisha: 1970-71 to 2019-20

Crops	India	West Bengal	Odisha
Rice	1.0874	1.0974	1.3217
Wheat	1.0577	1.1104	1.0740
Pulses	1.1005	1.1356	1.1269
Oil seeds	1.1453	1.4161	1.1519

(Source: author's own calculation based on secondary data)

Table 3 shows Coppock's Fluctuation Index for the yields of rice, wheat, pulses, and oilseeds in India and its two states, West Bengal and Odisha. The year-to-year fluctuations in the yields of rice, wheat, pulses, and oilseeds in India are 1.0874, 1.0577, 1.1005, and 1.1453, respectively. The Coppock's Fluctuation Index for the yields of rice, wheat, pulses, and oilseeds in West Bengal are 1.0974, 1.1104, 1.1356, and 1.4161, respectively, while in Odisha, the values are 1.3217, 1.0740, 1.1269, and 1.1519, respectively. The highest year-to-year fluctuation in yield is observed for oilseeds in West Bengal, with a value of 1.4161, while the lowest year-to-year fluctuation is found for wheat in India, with a value of 1.0577.

D. Analysis the Modified Coppock's Measure of Fluctuation of yield of Rice, Wheat, Pulses and Oil seeds in India, West Bengal and Odisha

The fluctuation from the trend is measured by the F_{RSS} measure of fluctuation. The year-to-year fluctuation is measured by the Coppock measure of fluctuation ($F_{Coppock}$). Since these two measures are not directly comparable because $F_{Coppock}$ is not unit-free, we need to consider the adjusted Coppock measure of fluctuation ($F'_{Coppock}$), as suggested by Mondal and Mondal Saha[6].

Table 4: Modified Coppock's fluctuation index of yield of Rice, Wheat, Pulses and Oil seeds in India, West Bengal and Odisha: 1970-71 to 2019-20

Crops	India	West Bengal	Odisha
Rice	0.0056	0.0061	0.0195
Wheat	0.0036	0.0068	0.0048
Pulses	0.0075	0.0098	0.0097
Oil seeds	0.0102	0.0257	0.0108

(Source: author's own calculation based on secondary data)

In our study, the modified Coppock fluctuation of the yields of rice, wheat, pulses, and oilseeds in India, West Bengal, and Odisha is shown in Table 4. The highest modified Coppock fluctuation is observed in the yield of oilseeds in West Bengal, with a value of 0.0257, while the lowest modified Coppock fluctuation is observed in the yield of wheat in India, with a value of 0.0036.

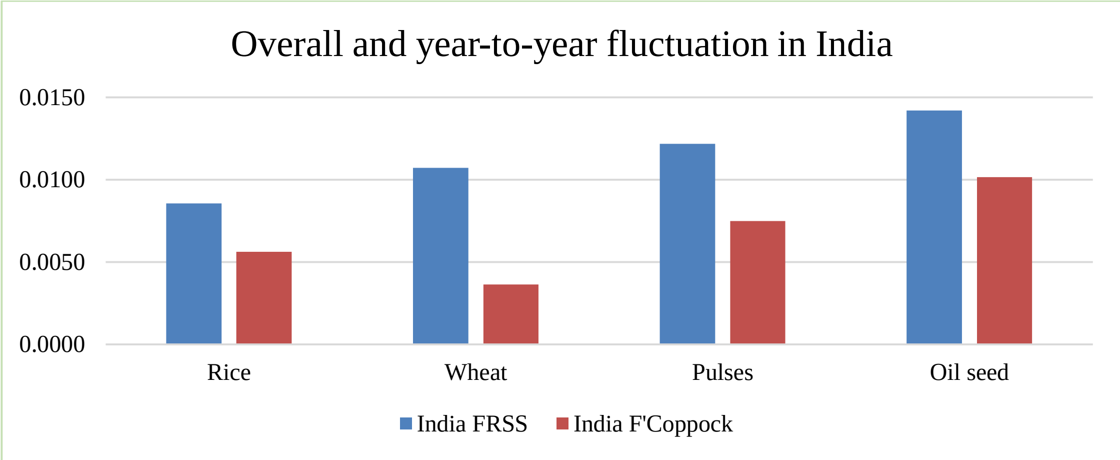
E. Analysis the F_{RSS} and Modified Coppock's Measure of Fluctuation of yield of Rice, Wheat, Pulses and Oil seeds in India, West Bengal and Odisha

Total fluctuation is measured by the F_{RSS} measure of fluctuation, and year-to-year fluctuation is measured by Coppock's Fluctuation Index. However, the two measures are not directly comparable. For this reason, we use the modified Coppock Fluctuation Index ($F'_{Coppock}$), as suggested by Mondal and Mondal Saha[6]

Table 5: F_{RSS} and $F'_{Cpppock}$ of yield of Rice, Wheat, Pulses and Oil seeds in India, West Bengal and Odisha: 1970-71 to 20019-20

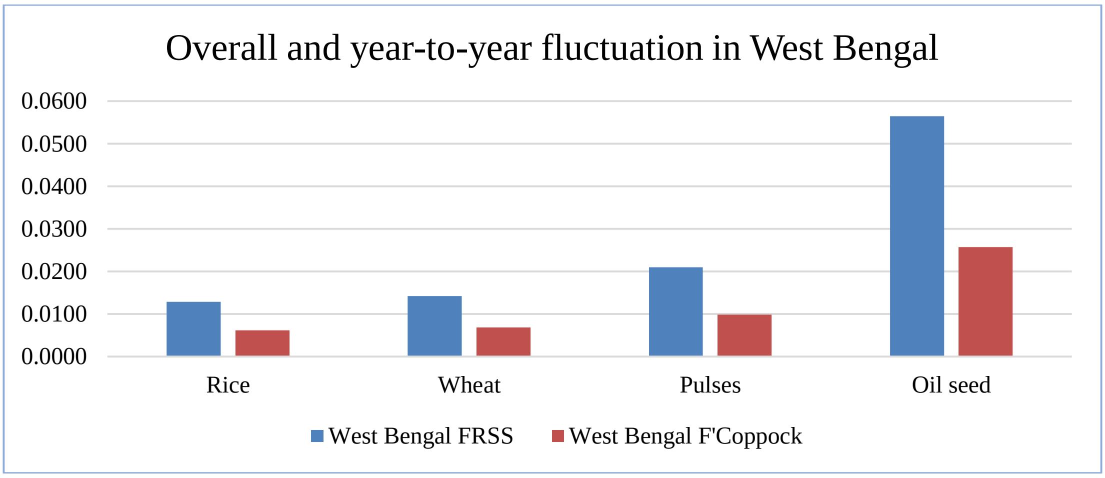
Crops	India		West Bengal		Odisha	
	F_{RSS}	$F'_{Copppck}$	F_{RSS}	$F'_{Copppck}$	F_{RSS}	$F'_{Copppck}$
Rice	0.0086	0.0056	0.0128	0.0061	0.0249	0.0195
Wheat	0.0107	0.0036	0.0142	0.0068	0.0158	0.0048
Pulses	0.0122	0.0075	0.0209	0.0098	0.0221	0.0097
Oil seeds	0.0142	0.0102	0.0565	0.0257	0.0231	0.0108

(Source: author's own calculation based on secondary data)



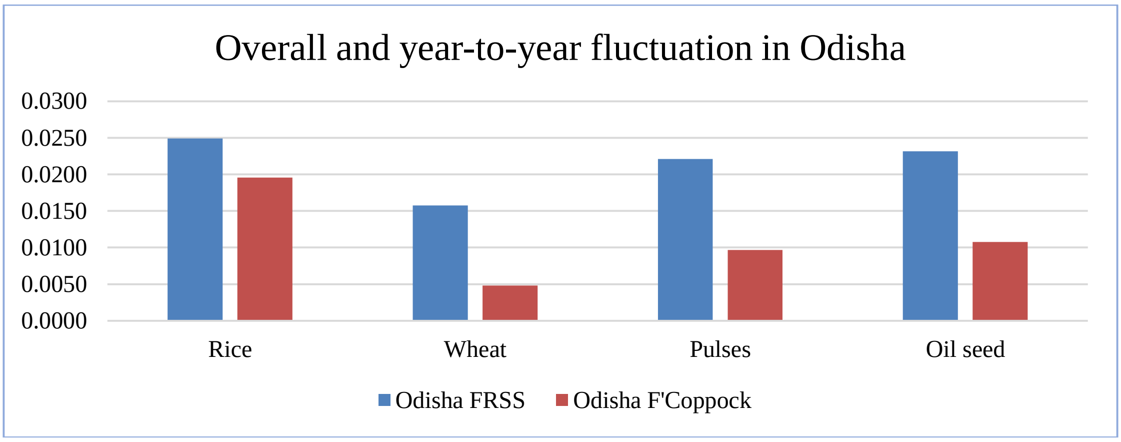
(Source: author's own calculation based on secondary data)

Figure 3: F_{RSS} and $F'_{Coppock}$ of yield of Rice, Wheat, Pulses and Oil seeds in India



(Source: author's own calculation based on secondary data)

Figure 4: F_{RSS} and $F'_{Coppock}$ of yield of Rice, Wheat, Pulses and Oil seeds in West Bengal



(Source: author's own calculation based on secondary data)

Figure 5: F_{RSS} and $F'_{Coppock}$ of yield of Rice, Wheat, Pulses and Oil seeds in Odisha

In our study, the total fluctuation, measured by F_{RSS}, for the yield of rice in India is found to be 0.0086, while the year-to-year fluctuation is 0.0056. The year-to-year fluctuation accounts for 65.55% of the total fluctuation, with the remaining 34.44% attributed to cyclical and irregular fluctuations. Table 5 and Figure 3 show that the highest modified Coppock Fluctuation Index ($F'_{Coppock}$) in India among all the crops in our study is for oilseeds, with a value of 0.0102, while the lowest is for wheat, with a value of 0.0036. Similarly, the modified Coppock's fluctuation for rice in West Bengal is 0.0061, which represents 47.85% of the total fluctuation. Table 5 and Figure 4 show that the highest modified Coppock Fluctuation Index in West Bengal among the four crops is for oilseeds, with a value of 0.0257, while the lowest is for rice, with a value of 0.0061. Table 5 and Figure 5 show that the highest modified Coppock Fluctuation Index in Odisha among all the crops in our study is for rice (0.0195), which accounts for 78.47% of the total fluctuation, while the lowest is for wheat (0.0048), which represents 30.61% of the total fluctuation.

Table 6: Average length of full cycles and $F'_{Coppock}$ of yield of Rice, Wheat, Pulses and Oil seeds in India, West Bengal and Odisha: 1970-71 to 20019-20

Crops	India		West Bengal		Odisha	
	Average length of cycles	$F'_{Coppock}$	Average length of cycles	$F'_{Coppock}$	Average length of cycles	$F'_{Coppock}$
Rice	4.65	0.0056	8.74	0.0061	3.25	0.0195
Wheat	17.36	0.0036	8.73	0.0068	21.34	0.0048
Pulses	5.29	0.0075	9.05	0.0098	10.41	0.0097
Oil seeds	3.91	0.0102	9.68	0.0257	9.25	0.0108

(Source: author's own calculation based on secondary data)

Table 6 shows the average length of full cycles and the modified Coppock Fluctuation Index ($F'_{Coppock}$) for the yield of rice, wheat, pulses, and oilseeds in India, West Bengal, and Odisha. Upon observing Table 6, we see that when the modified Coppock value is low, the average length of full cycles is high, and when the modified Coppock value is high, the average length of full cycles is low. This is due to the formula for the average length of full cycles: $\{2 * \left[\frac{F_{RSS}}{F'_{Coppock}}\right]^2\}$, as proposed by Mondal and Mondal Saha [6]. If the numerator is high and the denominator is low, the average length is high, while if the numerator is low and the denominator is high, the average length of full cycles is low. In India, the highest average length of full cycles among the four crops is for wheat, with a value of 17.36 years and a modified Coppock value of 0.0036. The lowest average length of full cycles is for oilseeds, at 3.91 years, with a modified Coppock value of 0.0102. Similarly, in West Bengal and Odisha, the highest average length of full cycles is for oilseeds and wheat, with values of 9.68 years and 21.34 years, respectively, while the lowest is for wheat and rice, with values of 8.73 years and 3.25 years.

V. CONCLUSION

This study analyses the growth patterns of the yield of rice, wheat, pulses, and oilseeds in India, West Bengal, and Odisha from 1970-71 to 2019-20. The analysis uses the Exponential Annual Growth Rate (EAGR) and Compound Annual Growth Rate (CAGR) for growth, and various fluctuation measures to assess fluctuation. Total fluctuation is measured using F_{RSS} and the Cuddy-Della Valle Index (CDVI), while year-to-year fluctuation is measured by Coppock's Fluctuation Index. However, these two measures are not directly comparable. To make them comparable, Coppock's measure is modified through rationalization, resulting in the adjusted Coppock measure. Additionally, the study calculates the average length of full cycles. The growth rate of rice yield in India is 1.86%, which is highly significant. Similarly, the growth rates of rice yield in West Bengal and Odisha are 2.15% and 1.93%, respectively, and both are highly significant. It is observed that the growth rate of rice yield in West Bengal is better than that in Odisha. The growth rates of wheat and pulses yields in Odisha are both negative and insignificant. In India, the growth rate of pulses is positive and significant but relatively low at 0.94%.

Fluctuation is measured using different fluctuation methods. First, total fluctuation is calculated using F_{RSS} and CDVI, with the values being nearly the same for both measures. In this study, the highest CDVI for yield across all four crops in India is for oilseeds (0.0143), while in West Bengal, the highest CDVI is also for oilseeds (0.0570), and in Odisha, it is for rice (0.0252). Year-to-year fluctuation is calculated using the Coppock Fluctuation Index. The Coppock Fluctuation Index for rice, wheat, pulses, and oilseeds in India is 1.0874, 1.0577, 1.1005, and 1.1453, respectively. In West Bengal, the values are 1.0974, 1.1104, 1.1356, and 1.4161, respectively, and in Odisha, the values are 1.3217, 1.0740, 1.1269, and 1.1519, respectively.

The F_{RSS} measure of fluctuation and the Coppock measure of fluctuation are not directly comparable because the Coppock measure is not unit-free. To address this issue, the adjusted Coppock measure of fluctuation ($F'_{Coppock}$) is used. The modified Coppock fluctuation values for the yield of rice, wheat, pulses, and oilseeds in India are 0.0056, 0.0036, 0.0075, and 0.0102, respectively. The ($F'_{Coppock}$) values for these crops in West Bengal are 0.0061, 0.0068, 0.0098, and 0.0257, respectively, and in Odisha, the values are 0.0195, 0.0048, 0.0097, and 0.0108, respectively.

The average length of full cycles is also calculated. The average length of full cycles for rice, wheat, pulses, and oilseeds in India is 6.65, 17.36, 5.29, and 3.91 years, respectively. In West Bengal, the average lengths are 8.74, 8.73, 9.05, and 9.68 years, respectively, and in Odisha, the values are 3.25, 21.34, 10.41, and 9.25 years, respectively.

Upon examining the values of ($F'_{Coppock}$) and the average length of full cycles, we observe that when the ($F'_{Coppock}$) value is low, the average length of full cycles is high, and when the ($F'_{Coppock}$) value is high, the average length of full cycles is low.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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