Journal of Experimental Agriculture International

Volume 46, Issue 9, Page 708-716, 2024; Article no.JEAI.123059
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Impact of Seasonal Shifts on Cereal Crop Acreage in Western Odisha, India: An Empirical Analysis

Moumita Baishya [a*], Gunturi Alekhya [b], Veershetty [a], G. Avinash [a] and Harish Nayak GH [c]

[a] The Graduate School, ICAR-Indian Agricultural Research Institute, New Delhi-110012, India.
[b] Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi-110012, India.
[c] University of Agricultural Sciences, Dharwad, Karnataka-580005, India.

Authors' contributions

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

Article Information

DOI: https://doi.org/10.9734/jeai/2024/v46i92868

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/123059

Original Research Article

Received: 01/07/2024
Accepted: 06/09/2024
Published: 06/09/2024

ABSTRACT

In recent years, India's agricultural landscape has undergone profound changes driven by a variety of factors. The sector in Odisha, in particular, is characterized by considerable risks and uncertainties, necessitating a thorough examination of growth and stability. This research offers an in-depth evaluation of the compound growth rate and Coppock's Instability Index for four principal cereal crops—rice and maize during the Kharif season, and ragi and wheat during the Rabi season—with a focus on crop area. Utilizing secondary data spanning from 1993-94 to 2022-23, this study analyzes and compares the area changes and instability across districts in Western Odisha. The study also includes a district-wise ranking based on these metrics, facilitating a comparison between the Kharif and Rabi seasons. The findings reveal distinct variations in crop area trends and instability, providing critical insights into the agricultural challenges and patterns within the region.

**Corresponding author: E-mail: moumitabaishya1194@gmail.com;*

***Cite as:** Baishya, Moumita, Gunturi Alekhya, Veershetty, G. Avinash, and Harish Nayak GH. 2024. "Impact of Seasonal Shifts on Cereal Crop Acreage in Western Odisha, India: An Empirical Analysis". Journal of Experimental Agriculture International 46 (9):708-16. https://doi.org/10.9734/jeai/2024/v46i92868.*

Keywords: Compound growth rate; Coppock's instability index; growth rate; CGR; temporal Analysis.

1. INTRODUCTION

Agriculture is a cornerstone of Odisha's economy, contributing approximately 17% to the state's Gross State Domestic Product (GSDP) and 18% to India's Gross Domestic Product (GDP). It plays a crucial role in ensuring food security and providing employment, with around 60% of the state's workforce engaged in agricultural activities and about 70% of the population involved either directly or indirectly. The state covers a total geographical area of 155.71 lakh hectares, with 61.80 lakh hectares under cultivation and 53.31 lakh hectares dedicated to crop production, representing 34% of the land area. Odisha is especially prominent in rice production, contributing nearly 10% of India's total rice yield, thanks to its favourable climate and fertile soils.

However, Odisha's agricultural sector faces significant challenges, including frequent natural disasters and irregular rainfall, which lead to variability and instability in crop areas. For instance, although the area under cultivation peaked at 114 lakh hectares in 2012-13, subsequent adverse conditions such as Cyclone Phailin and excessive rainfall in 2013-14 caused considerable disruptions. Despite these challenges, Odisha's agricultural sector has shown resilience through infrastructure improvements, technological advancements, and supportive policies. Key cereal crops, including rice, maize, and ragi, are integral to the agricultural landscape. These crops are essential as they provide approximately 60% of dietary energy and plant-based protein, with rice alone supplying 40% of protein in the Asian diet. Maize, as the third most significant food crop in India, also contributes substantially to the agricultural economy and employment, with potential for value-added products like quality protein maize (QPM) and baby corn.

Instability in crop area is a major issue, affecting market stability and leading to price volatility. Such variability impacts consumers through fluctuating food prices and can result in inefficient resource allocation by farmers. Understanding and addressing these fluctuations in crop area is crucial for effective agricultural planning and sustainable development. While research has been conducted in other regions such as Tamil Nadu, there is a notable lack of detailed studies on crop area variability for cereal crops in Odisha, particularly at the district level. Previous research has provided valuable insights into agricultural dynamics and instability. Studies like those by Dash et al. [1] and Ghosh and Sahu [2] have examined growth and instability in food grain and rice production, respectively, in various regions. Research by Dhakre and Amod [3] and Kachroo et al. [4] highlighted crop-specific challenges in maize across different states. Foundational methodologies for growth rate computation, explored by Gupta and Chandran [5] and Prajneshu and Chandran [6], have informed data analysis techniques. Additionally, regional studies by Singh et al. [7] and Tripathy and Mishra [8] emphasized crop variability in different states. This study aims to address this gap by analysing the compound growth rates and variability of crop areas for key cereal crops in Western Odisha, providing valuable insights to improve agricultural stability and development in the region [9,10,11].

2. MATERIALS AND METHODS

2.1 Data Collection

This research conducts a thorough examination of key cereal crops in Western Odisha, with a particular emphasis on rice, maize, ragi, and wheat. Spanning the agricultural years from 1993-94 to 2022-23, the study provides a comprehensive temporal analysis of trends and patterns associated with these crops. To account for the influence of seasonal variations, the research incorporates data from both the kharif and rabi seasons. By exploring these two distinct cropping periods, the study seeks to offer a nuanced understanding of the effects of seasonal factors on the growth, production, and yield of these essential cereal crops in the region [12,13,14].

2.2 Data Sources

The data utilized in this research were obtained from secondary sources provided by the Directorate of Agriculture and Food Production, Government of Odisha. The study primarily relies on the detailed datasets found in the Odisha Agriculture Statistics volumes, which offer extensive information on the production of selected cereal crops, meticulously compiled from various districts across Western Odisha. This comprehensive dataset serves as the foundation for the analysis of agricultural trends and performance in the region [15].

2.3 Analytical Methods

2.3.1 Compound Growth Rate (CGR)

Model Specification: The compound growth rate (CGR) of production for each cereal crop was estimated using an exponential growth model. The model is represented as:

$$Y_t = ab^t \quad (1)$$

where, Y_t represents the production of the cereal crop in year

t is the time element which takes the value 1,2,3………,n
a is the intercept,
b is the growth rate coefficient.

Logarithmic Transformation: To linearize the exponential growth model, a logarithmic transformation was applied:

$$\log Yt = Log\ a + tLog\ b \quad (2)$$

By defining

$Log\ Yt = Yt'$
$Log\ a = A'$
$Log\ b = B'$

the transformed equation becomes: $Yt' = A' + B't$

Estimation of Parameters: The parameters A' and B' were estimated using the least squares method. Two key equations were derived for this purpose

$$\sum_{t=1}^{n} Yt' = nA' + B' \sum_{t=1}^{n} t \quad (3)$$

$$\sum_{t=1}^{n} tYt' = A' \sum_{t=1}^{n} t + B' \sum_{t=1}^{n} t^2 \quad (4)$$

Solving these 4 equations and multiplying equation 3 by $\sum_{t=1}^{n} t$ on both sides and multiplying equation 4 by n on both sides we get,

$$B' = \frac{n \sum_{t=1}^{n} t\, Y_t' - \sum_{t=1}^{n} Y_t' \sum_{t=1}^{n} t}{n \sum_{t=1}^{n} t^2 - (\sum_{t=1}^{n} t)^2}$$

and

$$A' = \sum_{t=1}^{n} Y_t' \left(\sum_{t=1}^{n} Y_t' - B' \sum_{t=1}^{n} t\right)/n.$$

Compound Growth Rate = $(Antilog\ B - 1) \times 100$

2.3.2 Coppock's instability index

Coppock's instability index was used to assess the variability or instability in the production of cereal crops. Coppock's Instability Index = $Antilog\left(\sqrt{vlog} - 1\right) \times 100$

where, $vlog = \left(\sum_{t=1}^{n} log \frac{X_{t+1}}{X_t} - m\right)^2$, X_t denotes the production in year t and m is the mean of the logarithm of X_t.

3. RESULTS AND DISCUSSION

3.1 Compound Growth Rate and Instability Index of Area of Rice during Kharif and Rabi Season

Table 1. shows a negative compound growth rate (CGR) for rice cultivation during the kharif season across Odisha and most districts of Western Odisha, except Sambalpur and Sonepur, from 1993-94 to 2015-16. Sonepur had the highest CGR at 0.146% per annum, while Jharsuguda had the lowest at -0.226%. Sambalpur's CGR was positive but modest. Jharsuguda experienced the steepest decline, followed by Sundargarh (-0.166%) and Kalahandi (-0.124%).

Coppock's Instability Index, as presented in Table 1, indicates 10.216% variability in Odisha, with Jharsuguda showing the highest instability in Western Odisha at 11.839%, likely due to rainfall fluctuations.

During the rabi season, Table 1. reveals a positive CGR in rice cultivation for most of Odisha, except Deogarh, Jharsuguda, and Sundargarh. The state's CGR was 0.097% per annum, with Kalahandi leading Western Odisha at 3.130%, and Deogarh the lowest at 1.919%. Deogarh had the highest variability at 65.288%, possibly due to climatic factors.

Table 1. Compound Growth Rate and Coppock's Instability Index for area of rice inkharif and rabi seasons for the districts of western Odisha and the state as a whole

Districts	Kharif		Rabi	
	CGR	CII	CGR	CII
Balangir	-0.093	10.657	0.748	21.512
Bargarh	-0.033	10.315	0.269	11.159
Deogarh	-0.058	10.754	-1.919	65.288
Jharsuguda	-0.226	11.840	-0.770	23.339
Kalahandi	-0.124	10.524	3.130	21.629
Nuapada	-0.094	10.590	1.869	46.742
Sambalpur	0.001	10.616	0.389	16.325
Sonepur	0.146	10.510	0.484	11.509
Sundargarh	-0.166	10.580	-1.303	19.521
Odisha	**-0.133**	**10.216**	**0.097**	**12.594**

Table 2. Compound Growth Rate and Coppock's Instability Index for area ofmaize in kharif and rabi seasons for the districts of western Odisha and the state as a whole

Districts	Kharif		Rabi	
	CGR	CII	CGR	CII
Balangir	0.787	11.211	0.723	14.173
Bargarh	0.891	11.732	1.008	13.985
Deogarh	0.928	12.645	0.473	12.102
Jharsuguda	1.544	13.371	0.499	16.172
Kalahandi	1.558	12.690	2.336	15.946
Nuapada	1.438	13.227	2.109	18.167
Sambalpur	1.526	13.713	1.625	16.758
Sonepur	0.753	15.845	0.469	15.314
Sundargarh	0.226	11.103	0.471	14.959
Odisha	**0.510**	**10.653**	**0.972**	**12.139**

3.2 Compound Growth Rate and Instability Index of Area of Maize during Kharif and Rabi Season

Table 2. illustrates the compound growth rate of maize area in Western Odisha during the study period (1993-94 to 2015-16). In the kharif season, a positive growth trend is evident across Odisha and all districts in Western Odisha. Kalahandi district recorded the highest compound growth rate at 1.558% per annum, while Sundargarh registered the lowest at 0.226%. Sundargarh also exhibited the minimal growth rate, followed by Sonepur (0.753%) and Balangir (0.787%).

Coppock's instability index, as shown in Table 2, indicates a variability of 10.653% in maize cultivation area across Odisha. In Western Odisha, Sonepur district experienced the highest variability at 15.845%, with Sundargarh having the lowest at 11.103%. This heightened variability could be attributed to inconsistent rainfall patterns.

During the rabi season, maize area also demonstrated positive growth in Odisha and its districts in Western Odisha. The state's compound growth rate was 0.972% per annum, with Kalahandi leading at 2.336% and Sonepur at the lowest, 0.469%. Sundargarh (0.471%) and Deogarh (0.473%) closely followed Sonepur. According to Coppock's instability index in Table 2, the variability in maize area during the rabi season was 12.139% across Odisha. In Western Odisha, Nuapada district exhibited the highest variability at 18.167%, likely due to rainfall fluctuations or other climatic influences.

3.3 Compound Growth Rate and Instability Index of Yield of Ragi during Kharif and Wheat in Rabi Season

Table 3. demonstrates a negative compound growth rate (CGR) in the area under ragi cultivation during the kharif season across Odisha, including all districts in Western Odisha, with the exception of Sundargarh, which

exhibited a positive CGR during the study period (1993-94 to 2015-16). Sundargarh achieved the highest CGR in Western Odisha at 0.529% per annum, whereas Deogarh recorded the lowest at -2.843% per annum. Deogarh also had the minimal CGR, closely followed by Sambalpur and Jharsuguda, both at -2.623%.

Coppock's Instability Index, detailed in Table 3, reveals a statewide variability of 10.713% in ragi cultivation area. Within Western Odisha, Nuapada exhibited the highest variability at 25.798%, while Sundargarh had the lowest at 12.695%. This elevated variability in ragi area is likely due to fluctuations in rainfall.

Additionally, Table 3. highlights a declining negative CGR for wheat area during the rabi season across Odisha and most districts in Western Odisha, with Kalahandi as the exception, showing a positive CGR. The CGR for wheat area in Odisha was -0.691% per annum over the study period. In Western Odisha, Kalahandi recorded the highest CGR at 0.664% per annum, while Jharsuguda had the lowest at -1.795% per annum. Jharsuguda's CGR was the lowest, followed by Balangir (-1.716%) and Sonepur (-1.387%). Coppock's Instability Index also reflects the variability in wheat cultivation area during this period, with the state showing a variability of 13.035%. Jharsuguda had the highest variability in Western Odisha at 29.954%, likely due to rainfall variability or other climatic factors.

3.4 Rank Classification of the Districts of Western Odisha According to the Growth Rate and Instability Index of Major Cerealcrops

According to Table 4, districts are ranked based on the compound growth rate and Coppock's instability index for major cereal crops in the kharif and rabi seasons.

Table 3. Compound Growth Rate and Coppock's Instability Index for area of ragi in kharif and wheat in rabi seasons for western Odisha and the state as awhole

Districts	Ragi (Kharif)		Wheat (Rabi)	
	CGR	CII	CGR	CII
Balangir	-2.598	15.192	-1.717	13.824
Bargarh	-0.043	14.704	-1.166	16.514
Deogarh	-2.843	15.685	-1.340	24.676
Jharsuguda	-2.623	17.148	-1.795	29.954
Kalahandi	-1.797	12.705	0.664	19.315
Nuapada	-0.859	25.798	-0.942	14.712
Sambalpur	-2.623	17.148	-0.279	15.514
Sonepur	-0.406	17.574	-1.387	12.310
Sundargarh	0.529	12.695	-0.631	12.706
Odisha	**-0.311**	**10.713**	**-0.691**	**13.035**

Table 4. Classification of the districts of western Odisha on the basis of their ranks with respect to Compound Growth Rate and Coppock's Instability Index for area under rice in kharif and rabi seasons

Districts	Kharif		Rabi	
	Rank of the districts according to CGR	Rank of the districts accordingto CII	Rank of the districts according to CGR	Rank of the districts accordingto CII
Balangir	5	3	3	5
Bargarh	3	9	6	9
Deogarh	4	2	9	1
Jharsuguda	9	1	7	3
Kalahandi	7	7	1	4
Nuapada	6	5	2	2
Sambalpur	2	4	5	7
Sonepur	1	8	4	8
Sundargarh	8	6	8	6

In the kharif season, Sonepur ranks highest for the compound growth rate of rice area (Rank 1) but is positioned at Rank 8 for Coppock's instability index, reflecting strong growth yet significant instability. Jharsuguda exhibits minimal growth and high instability, whereas Kalahandi maintains consistent rankings for both metrics.

For the rabi season, Deogarh shows the lowest ranking for the compound growth rate while ranking high for instability, indicating poor growth and high instability in rice area. Sundargarh demonstrates stable rankings across both metrics, suggesting consistent rice area performance. Nuapada ranks highly for both the compound growth rate and instability, signifying unstable rice area performance.

Table 5. highlights the district rankings based on compound growth rate and Coppock's Instability Index for maize crops during the kharif season. Kalahandi achieves the highest ranking (Rank 1) for compound growth rate in maize area but ranks lower (Rank 5) for Coppock's Instability Index, reflecting strong growth performance coupled with moderate instability. In contrast, Sonepur exhibits a lower rank in compound growth rate, indicating minimal growth and significant instability. Sundargarh maintains consistent rankings across both metrics, suggesting uniform performance in growth and stability.

In the rabi season, Table 5. reveals the district rankings for compound growth rate and Coppock's Instability Index for rice production. Kalahandi leads with the highest ranking (Rank 1) in compound growth rate for rice production but shows moderate instability (Rank 4), indicating excellent growth performance with some instability. Nuapada demonstrates high instability with a top rank (Rank 1) in Coppock's Instability Index despite a strong compound growth rate (Rank 2), suggesting considerable volatility. Jharsuguda shows significant instability in both seasons, reflecting substantial variability in maize crop area performance.

The data in Table 6. reveals the following insights: In the kharif season, Sundargarh ranks highest (1) for the compound growth rate of ragi area and is positioned 9th for Coppock's Instability Index, indicating excellent performance and high stability in ragi cultivation. Conversely, Sonepur ranks 3rd for compound growth but 2nd for Coppock's Instability Index, reflecting a strong growth rate paired with high instability. Balangir maintains a consistent rank of 6 for both the compound growth rate and Coppock's Instability Index, suggesting uniform performance in growth and stability.

For the rabi season, Kalahandi achieves the highest rank (1) in compound growth rate for wheat area but is ranked 3rd in Coppock's Instability Index, signifying a leading growth rate with notable instability. In contrast, Jharsuguda ranks 9th for compound growth rate and 1st for Coppock's Instability Index, illustrating poor growth performance and substantial instability.

Table 5. Classification of the districts of western Odisha on the basis of their ranks with respect to Compound Growth Rate and Coppock's Instability Index for area under maize in kharif and rabi seasons

Districts	Kharif		Rabi	
	Rank of the districts according to CGR	Rank of the districts according to CII	Rank of the districts according to CGR	Rank of the districts according to CII
Balangir	7	8	5	7
Bargarh	6	7	4	8
Deogarh	5	6	7	9
Jharsuguda	2	3	6	3
Kalahandi	1	5	1	4
Nuapada	4	4	2	1
Sambalpur	3	2	3	2
Sonepur	8	1	9	5
Sundargarh	9	9	8	6

Table 6. Classification of the districts of western Odisha on the basis of their ranks with respect to Compound Growth Rate and Coppock's Instability Index for area under ragi in kharif and wheat in rabi seasons

Districts	Ragi (Kharif)		Wheat (Rabi)	
	Rank of the districts according to CGR	Rank of the districts according to CII	Rank of the districts according to CGR	Rank of the districts according to CII
Balangir	6	6	8	7
Bargarh	2	7	5	4
Deogarh	9	5	6	2
Jharsuguda	7	3	9	1
Kalahandi	5	8	1	3
Nuapada	4	1	4	6
Sambalpur	8	4	2	5
Sonepur	3	2	7	9
Sundargarh	1	9	3	8

3.5 Study of Comparison of CGR and Instability Index of Rice and Maize between Kharif and Rabi Seasons

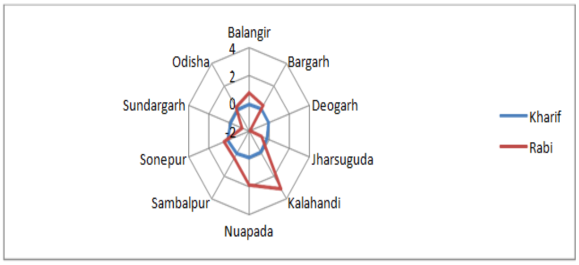

Fig. 1. Radar graph showing Compound Growth Rate of area under rice crop during kharif and rabi season for the districts of Western Odisha and the stateas a whole

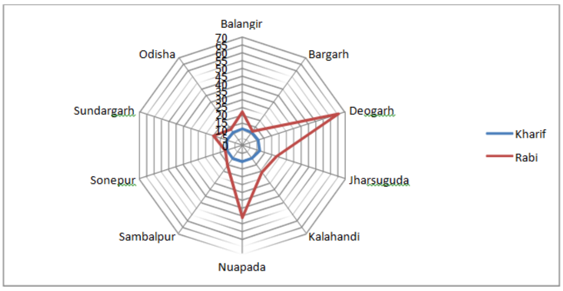

Fig. 2. Radar graph showing Coppocks Instability Index of area under rice crop during kharif and rabi season for the districts of Western Odisha and the state as a whole

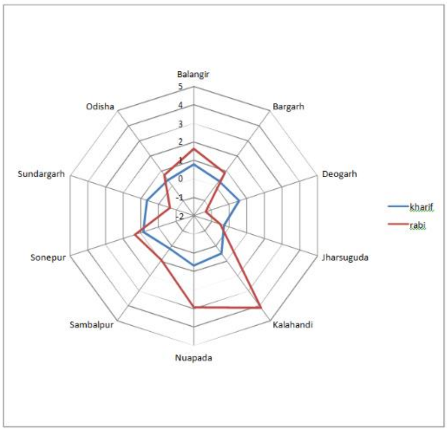

Fig. 3. Radar graph showing Compound Growth Rate of area under maize crop during kharif and rabi season for the districts of Western Odisha and the state as a whole

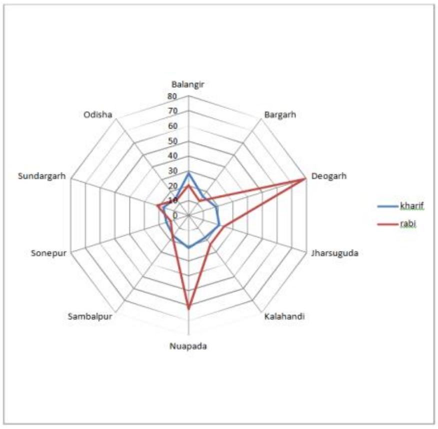

Fig. 4. Radar graph showing Coppocks Instability Index of area under maize crop during kharif and rabi season for the districts of Western Odisha and the state as a whole

Fig. 1. reveals that the Compound Growth Rate (CGR) for rice cultivation area within the state is lower during the kharif season compared to the rabi season. This pattern is observed consistently across the districts of Western Odisha, including Balangir, Bargarh, Kalahandi, Nuapada, Sambalpur, and Sonepur, where the CGR of rice area during kharif is inferior to that of rabi. Conversely, the districts of Deogarh, Jharsuguda, and Sundargarh demonstrate a divergent trend, with a higher CGR for rice area during kharif compared to rabi. Specifically, Kalahandi exhibits a pronounced difference between the two seasons, with the area under rabi rice significantly surpassing that of kharif.

The analysis depicted in Fig. 2. reveals that the instability in the area under rice cultivation is notably lower during the kharif season compared to the rabi season across the state. This trend is uniformly observed across all districts of Western Odisha, including Balangir, Bargarh, Deogarh, Jharsuguda, Kalahandi, Nuapada, Sambalpur, Sonepur, and Sundargarh, where the instability in the area under rice is less pronounced in the kharif season than in the rabi season. Nevertheless, districts such as Deogarh and Nuapada exhibit markedly higher instability during the rabi season compared to kharif, indicating a substantial variation between the two seasons. In contrast, districts like Bargarh and Sonepur demonstrate minimal variation between the kharif and rabi seasons.

Fig. 3. reveals that the Compound Growth Rate of maize crop area in the state is lower during the kharif season compared to the rabi season. This trend is consistent across the districts of Western Odisha, including Balangir, Bargarh, Kalahandi, Nuapada, Sambalpur, and Sonepur, where the growth rate of maize area is notably less during kharif than in rabi. Conversely, districts such as Deogarh, Jharsuguda, and Sundargarh exhibit an opposite pattern, with a higher Compound Growth Rate of maize area during kharif compared to rabi. Notably, Kalahandi and Nuapada demonstrate a significant disparity in the Compound Growth Rate between the kharif and rabi seasons.

Fig. 4. reveals that maize crop area instability in the state is reduced during the rabi season compared to the kharif season. This pattern is consistent in several districts of Western Odisha, including Balangir, Bargarh, and Sonepur, where instability in maize crop area is lower in rabi than in kharif. However, districts such as Deogarh, Jharsuguda, Kalahandi, Nuapada, Sambalpur, and Sundargarh experience greater instability during the rabi season relative to kharif. Notably, the districts of Deogarh and Nuapada exhibit substantial fluctuations in maize production between the kharif and rabi seasons.

4. CONCLUSIONS

This study elucidates the variability in the compound growth rate (CGR) and instability of cereal crops in Western Odisha. During the kharif season, rice exhibits a generally negative CGR across Odisha, with Jharsuguda experiencing the steepest decline and Sonepur showing modest positive growth. The Coppock’s Instability Index indicates significant variability in Jharsuguda. Conversely, the rabi season shows a positive CGR for rice throughout most regions, particularly in Kalahandi. However, Deogarh exhibits substantial instability. For maize, the kharif season reveals a positive growth trend, with Kalahandi demonstrating the highest CGR. Sonepur, however, shows considerable instability. The rabi season also reflects positive growth in maize, with Kalahandi leading, though instability is notably high in Nuapada. Ragi cultivation during the kharif season generally exhibits negative growth rates, except in Sundargarh, which shows a positive trend. Wheat cultivation in the rabi season displays a decline in CGR across most districts, with Kalahandi as the notable exception. Instability is pronounced in Jharsuguda for both ragi and wheat. These findings underscore the significant spatial and temporal variability in crop growth and instability, necessitating region-specific agricultural strategies to mitigate the impact of climatic and environmental factors. Future research should focus on developing adaptive agricultural strategies and policies that address region-specific climatic and environmental factors to enhance the stability and growth of cereal crops in Western Odisha.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare 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 this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Dash A, Dhakre DS, Bhattacharya D. Study of growth and instability in food grain production of Odisha: A statistical approach. Environment and Ecology. 2017; 35(4D):354-3551.
2. Ghosh S, Sahu SK. An analysis of growth and instability in rice production in West Bengal, India. Journal of Agricultural Economics and Development, 2022; 11(1):42-58.
3. Dhakre DS, Amod S. Growth analysis of area, production, and productivity of maize in Nagaland. Agricultural Science Digest. 2010;30(2):142-146.
4. Kachroo R, Sharma SK, Pandit B. Study on growth and instability of maize in Jammu and Kashmir. Economic Affairs. 2013;58(1):21-28.
5. Gupta P, Chandran KP. Computation of compound growth rates in agriculture. Agricultural Economics Research Review. 2005;18:317-324.
6. Prajneshu, Chandran KP. Computation of compound growth rates in agriculture revisited. Agricultural Economic Research Review. 2005;18(2):317-324.
7. Singh NP, Saran SMG, Handa DP, Pal Singh, Pramod K. Growth rate and stability of different cereal crops. Annual Agriculture Research. 2003;24(3): 666-670.
8. Tripathy SY, Mishra SN. Growth and instability of ragi production in Orissa. Agricultural Situation in India. 1997;54(1):77-79.
9. Mander GS, Sharma JL. Production performance of cereal crops in India – State-wise analysis. Agricultural Situation in India. 1995;2(2)57-62.
10. Nandi PK, Kant GK. Study on growth models and critical analysis with reference to Andhra Pradesh and India. IASRI; 2001.
11. Prasher RS, Bahl SK. Growth and instability in Himachal Pradesh agriculture: A decomposition analysis. Bihar Journal of Agricultural Marketing. 1998;6(1):43-49.
12. Shankar G, Shrivastava A, Saxena RR. Growth and instability: An inter-zonal analysis of kharif and rabi crops in Chhattisgarh. Research Journal of Engineering and Technology. 2010;1(1):18-23.
13. Singh G, Chandran H. Growth trends in area and productivity of total food grain production in Madhya Pradesh. Agricultural Situation in India. 2001;57(1):597-602.
14. Toncheva R, Samalieva A, Klevtzov A. Trends of wheat yield variability by planning region of Bulgaria for 1960-2006. 2008;45(4):297-301.
15. Vani BP, Vyasulu V. Growth variability and instability of three major cereal crops in Karnataka – A district level analysis from 1955-56 to 1989-90. Economic and Political Weekly. 1996;31(26):A74-A83.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/123059