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A Study of Fluctuation and Development Trend in Kharif Rice Cultivation in Odisha, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

It has been a concern in Odisha to see stable agricultural growth rates. Since rice is the main crop grown in the state, the current study's goals are to determine the district wise growth rate of area, production, and yield of kharif rice as well as to determine the degree of instability in those districts of Odisha. The study is based on secondary source of data on area, yield and production of kharif rice in the districts of Odisha from the period 1994-95 to 2017-18. The data are obtained from various volumes of Odisha Agriculture Statistics published by Directorate of Agriculture and Food Production, Government of Odisha. The growth rates for area, production and yield of kharif rice were computed for the districts of Odisha using exponential model. Cuddy Della Valle's instability index was used to analyze the instability in area, production and yield of kharif rice in districts of Odisha. The compound growth rate in case of area was highest in Malkangiri and Subarnapur Districts. Lowest growth rate found in Kandhamal district. Compound growth rate for production are significant and highest in Subarnapur, Sundargarh, Jagatsinghpur and Boudh districts. Maximum

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districts showing positive growth rate in production and yield. Instability index for area of kharif rice in all districts of Odisha is insignificant except Bargarh and Jharsuguda which have significant Instability Index, which reveals that for the State, area is more stable as compared to that of yield and production. Despite stability of area, the instability of yield leads to instability of production.

Keywords: Growth rate; instability; production; significant.

1. INTRODUCTION

"The Indian economy is heavily reliant on the agricultural sector. More than 70% of rural households are dependent on agriculture. As it accounts for 17% of the country's GDP and employs roughly 58% of the workforce, agriculture is a significant component of the Indian economy. The eastern most state of India, Odisha is primarily an agricultural nation. Agribusiness is the main source of income for more than 83% of the country's inhabitants, who reside in rural areas. It is crucial for eradicating poverty and creating inclusive growth that the agriculture sector performs well since it determines the population's access to food and nutrition. Odisha have total production of kharif rice during 2020-21 is estimated at 102.36 million tonnes. Odisha is prone to harsh weather, but because to scientific interventions and successful programs, the state produced 13.606 million tonnes of food grains in 2022–23, the most ever in a single year. Odisha has a significant and extensive rice farming industry. A total of 90% of the state's rice-growing land is devoted to low- and very-productive productivity groups" [1,2]. Consequently, compared to the area planted with rice, the State's overall rice production is very little. The State does not have any high or medium productivity groupings. The State's average production over the past three years has been 1,124 kg/ha, which is almost 42% less than the country as a whole, which has averaged 1,947 kg/ha [3,4].

The study of growth and variability in area, production and yield of rice is very important for effective planning and strategy formulation. Various researchers have been contributing in this area of research. Jambhulkar et.al [5] studied "the growth rate and instability analysis of area, production and yield of Rice in Odisha state of India". Sunandini et.al [6] worked on "analysis of trends, Growth and instability in rice production in Andhra Pradesh using Compound growth rate and Cuddy Della Instability index. Despite tremendous improvements in agricultural productivity, not all of Odisha's districts have seen the same level of development. The analysis of patterns in rice production, area, and productivity in the state as well as in significant districts becomes important in this context. The area, production, and yield of rice were observed to be unstable for a number of reasons". Although there is a clear need for the agriculture sector to expand, Odisha's agricultural growth is more unpredictable because of the rising production instability. So, in order to analyse the factors, a study was conducted with the goals of examining the growth rate in the area, production, and productivity of the Odisha rice crop as well as the long-term stability of those rates.

2. MATERIALS AND METHODS

The study is based on secondary source of data on area, yield and production of rice crop for kharif rice in the districts of Odisha from the period 1994-95 to 2017-18. The data are obtained from various volumes of Odisha Agriculture Statistics published by Directorate of Agriculture and Food Production, Government of Odisha.

2.1 Growth Rate Analysis

In the present study, compound growth rate of area, production and yield for rice for each period were estimated to study the growth in area, production and yield of rice. The district wise compound growth rates were estimated with the help of following exponential model

$$Y_t = ab^t$$

$$\ln Y_t = \ln a + \ln b \qquad \text{Dash, et. al, [7]}$$

Where Y is the time series data on rice production, area, and yield by district t is the time term, and an is the constant coefficient. For a specific absolute change in the value of the explanatory variable t, the slope coefficient b calculates the relative change in Y. One can obtain the percentage change or growth rate in Y for an absolute change in the time variable t by multiplying the relative change in Y by 100.

The immediate rate of growth is measured by the slope coefficient. following formula can be used

to compute the compound growth rate r: Compound growth rate (C.G.R) = (b-1) × 100

2.2 Instability Analysis

The most widely used and widely accepted metric of instability for time series data is the Cuddy-Della Instability Index. John Cuddy and Della created the indices in the beginning to evaluate the level of instability in time series data. This index is a more accurate measurement than the coefficient of variation since it is automatically corrected for trend, which is frequently seen in time series data. This metric comprised any component that may be referred to as "white noise" as well as all cyclical fluctuations contained in the time series data, whether regular or irregular.

Cuddy – Della Instability (CDII) is given as,

$$\text{CDII} = \text{CV} \times \sqrt{1 - R^2}$$ Kumar et al., [8]; Rout and Dash, [9]

Where,
CV = Coefficient of variation = $\frac{\sigma}{\bar{Y}}$ 100
σ = Standard Deviation of Mean Area/ Yield/ Production;
$\bar{Y}$ – Mean Area / Yield/ Production
R^2-Coefficient of determination from a time trend regression adjusted for its degree of freedom

2.3 Test of Significance of Difference in Sample Variances of Area/Yield/ Production for Two Sub-Periods

Sample variance (s^2) of area/yield/production is given by:

$$s^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n - 1}$$

Sample variance provide an estimate of population variance

F-test is used to compare the two variances

The test procedure is as follows:

Null hypothesis; H_0: $\frac{\sigma_1^2}{\sigma_2^2}$ = 1 (where σ_1^2andσ_2^2 are two population variances)

Alternative hypothesis; H_1: $\frac{\sigma_1^2}{\sigma_2^2} \neq 1$ (two tailed test)
Test statistic F is given by

$F = \frac{{s_1}^2}{{s_2}^2}$ (If ${s_1}^2 > {s_2}^2$) or $F = \frac{{s_2}^2}{{s_1}^2}$ (If ${s_2}^2 > {s_1}^2$) Rangaswamy, [10]

${s_1}^2$is the sample variance of sub-periodI

${s_2}^2$is the sample variance of sub-periodII

$${s_1}^2 = \frac{1}{n_1 - 1}\left\{\sum_{i=1}^{n_1} {x_{1i}}^2 - \frac{\left(\sum_{i=1}^{n_1} x_{1i}\right)^2}{n_1}\right\} ;$$

$${s_2}^2 = \frac{1}{n_2 - 1}\left\{\sum_{i=1}^{n_2} {x_{2i}}^2 - \frac{\left(\sum_{i=1}^{n_2} x_{2i}\right)^2}{n_2}\right\}$$

level of significance, α : 0.05 (5%)

3. RESULTS AND DISCUSSION

Table 1 shows the districts wise growth rate of area, production and yield of kharif rice in Odisha. It is found from the table that compound growth rate for area of kharif rice in all districts of Odisha is negative and significant. Few districts which show positively significant like Malkangiri and Sambalpur. Compound growth rate for production is found to be positive for nearly 50 per cent of the districts, whereas the remaining districts show insignificant growth rate. The compound growth rate for yield is positive for most of the districts except Angul, Bargarh, Bolangir, Ganjam, Jharsuguda, Kandhamal, Khordha, Nayagarh, Nuapada and Sambalpur which show insignificant growth rate.

Fig. 1 shows the graphical presentation of compound growth rate of area, production and yield of kharif rice for different districts of Odisha.

Table 2 shows the districts wise instability index of area, production and yield of kharif rice in Odisha. The study of the table shows that the instability index for area of kharif rice in all districts of Odisha is insignificant except Bargarh and Jharsuguda which have significant Instability Index, which reveals that for the state, area is more stable as compared to that of yield and production. Despite stability of area, the instability of yield leads to instability of production.

Fig. 2 shows the graphical presentation of instability index of area, production and yield of kharif rice for different districts of Odisha.

Table 1. District wise growth rate of area, production and yield of kharif rice in Odisha

Si No	Districts	Area	Production	Yield	Si No	Districts	Area	Production	Yield
1	Angul	-1.43*	1.03	2.49	16	Kandhamal	-1.88*	-0.65	1.24
2	Balesore	-0.93*	2.19*	3.16*	17	Kendrapara	-0.51*	2.42	2.95*
3	Bargarh	-1.03	-0.86	0.17	18	Keonjhar	-0.93*	2.5*	3.47*
4	Bhadrak	-0.28*	2.21*	2.51*	19	Khurda	-1.11*	0.91	2.05
5	Bolangir	-0.69*	2.94	3.65	20	Koraput	-0.72*	1.76*	2.5*
6	Boudh	-0.25	3.26*	3.52*	21	Malkangiri	0.57*	2.71*	2.12*
7	Cuttack	-1.07*	2.19*	3.23*	22	Mayurbhanj	-0.47*	1.86*	2.35*
8	Deogarh	-0.24	3.05*	3.3*	23	Nabarangpur	-0.45*	2.19*	2.66*
9	Dhenkanal	-2.36*	1.44	3.89*	24	Nayagarh	-0.38*	0.4	0.79
10	Gajapati	-0.08	-0.13	-0.04	25	Nuapada	-0.49*	2.31	2.83
11	Ganjam	-0.64*	0.16	0.82	26	Puri	-1.83*	0.95	2.84*
12	Jagatsinghpur	-1.32*	3.42*	4.81*	27	Rayagada	-0.45	1.97*	2.44*
13	Jajpur	-1.27*	1.07	2.37*	28	Sambalpur	0.04	0.6	0.56
14	Jharsuguda	-1.1*	-0.14	0.97	29	Subarnapur	0.55*	3.58*	3.01*
15	Kalahandi	-0.83*	2.74*	3.61*	30	Sundargarh	-0.74*	3.31*	4.08*
*	Odisha	-0.69*	1.87*	2.58*					

**significance@5%*

Table 2. District wise instability index of area, production and yield of kharif rice

Si No	Districts	Area	Production	Yield	Si No	Districts	Area	Production	Yield
1	Angul	8.72	41.68*	43.05*	16	Kandhamal	11.98	24.89*	19.75*
2	Balesore	3.91	29.96*	29.7*	17	Kendrapara	5.74	30.57*	30.04*
3	Bargarh	15.2*	35.8*	32.29*	18	Keonjhar	4.98	26.93*	26.35*
4	Bhadrak	3.8	24.32*	24.69*	19	Khurda	6.53	30.51*	31.17*
5	Bolangir	6.51	55.97*	55.66*	20	Koraput	5.57	18.22*	14.96*
6	Boudh	7.12	35.94*	36.61*	21	Malkangiri	5.23	29.72*	28.37*
7	Cuttack	5.57	28.67*	29.69*	22	Mayurbhanj	4.57	25.81*	24.93*
8	Deogarh	7.15	44.26*	41.75*	23	Nabarangpur	6.56	32.17*	34.04*
9	Dhenkanal	8.3	35.36*	35.16*	24	Nayagarh	4.52	36.62*	36.98*
10	Gajapati	7.04	29.82*	26.27*	25	Nuapada	5.16	44.75*	44.19*
11	Ganjam	5.8	40.42*	39.35*	26	Puri	7.27	31.62*	34.63*
12	Jagatsinghpur	5.32	28.17*	30.8*	27	Rayagada	8.81	28.59*	24.99*
13	Jajpur	6.21	29.35*	29.28*	28	Sambalpur	5.98	33.42*	33.39*
14	Jharsuguda	13.4*	40.54*	40.8*	29	Subarnapur	4.01	33.65*	32.33*
15	Kalahandi	6.15	37.18*	37.65*	30	Sundargarh	4.31	35.45*	37.21*
*	Odisha	2.49	21.81*	21.93*					

**significance@5%*

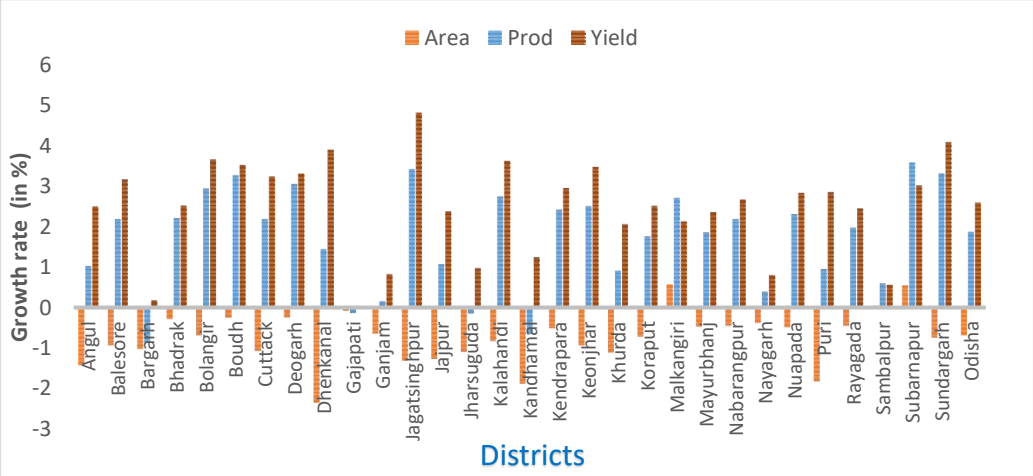

Fig. 1. Multiple bar diagram showing the compound growth rate (in %) of area, production and yield of kharif rice in the districts of Odisha

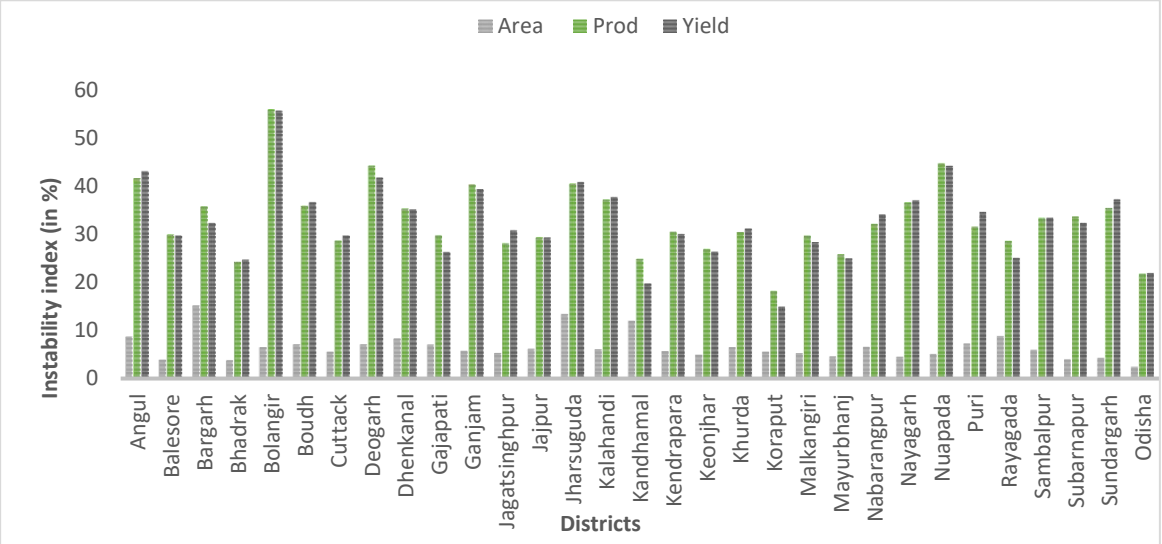

Fig. 2. Multiple bar diagram showing the instability index (in %) of Area, Production, Yield of kharif rice in the districts of Odisha

Table 3. Grouping of the districts of odisha based on compound growth rate and instability index of area of kharif rice

1A	Jharsuguda
1B	Angul, Balasore, Bhadrak, Bolangir, Cuttack, Dhenkanal, Ganjam, Jagatsinghpur, Jajpur, Kalahandi, Kandhamal, Kendrapara, Keonjhar, Khurda, Koraput, Mayurbhanj, Nabarangpur, Nayagarh, Nuapada, Puri, Sundargarh
2A	No districts
2B	Malkangiri, Sonepur
3A	Bargarh
3B	Boudh, Deogarh, Gajapati, Rayagarh, Sambalpur

1A= negative growth rate and significant instability
1B = negative growth rate and non-significant instability
2A= positive growth rate and significant instability
2B=positive growth rate and non-significant instability
3A = non-significant growth rate and significant instability
3B = non-significant growth rate and non-significant instability

Table 4. Grouping of the districts of Odisha based on compound growth rate and instability index of production of kharif rice

1A	No districts
1B	No districts
2A	Balasore, Bhadrak, Boudh, Cuttack, Deogarh, Jagatsinghpur, Kalahandi, Keonjhar, Koraput, Malkangiri, Mayurbhanj, Nabarangpur, Rayagada, Sonepur, Sundargarh
2B	No districts
3A	Angul, Bargarh, Bolangir, Dhenkanal, Gajapati, Ganjam, Jajpur, Jharsuguda, Kandhamal, Kendrapara, Khurda, Nayagarh, Nuapada, Puri, Sambalpur
3B	No districts

1A - negative growth rate & significant instability
1B = negative growth rate & non-significant instability
2A= positive growth rate & significant instability
2B=positive growth rate & non-significant instability
3A = non-significant growth rate & significant instability
3B = non-significant growth rate & non-significant instability

Table 3 shows the grouping of the districts of Odisha based on compound growth rate and instability index of area of kharif rice. Jharsuguda has negative growth rate and significant instability index whereas no districts showing positive growth rate with significant instability index. Malkangiri and Saharanpur have positive growth rate with non-significant instability index.

Table 5. Grouping of the districts of Odisha based on compound growth rate and instability index of yield of kharif rice

1A	No districts
1B	No districts
2A	Balasore, Bhadrak, Boudh, Cuttack, Deogarh, Dhenkanal, Jagatsinghpur, Jajpur Kalahandi, Kendrapara, Keonjhar, Koraput, Malkangiri, Mayurbhanj, Nabarangpur Puri, Rayagada, Sonepur, Sundargarh,
2B	No districts
3A	Angul, Bargarh, Bolangir, Gajapati, Ganjam, Jharsuguda Kandhamal, Khurda, Nayagarh, Nuapada, Sambalpur
3B	No districts

1A: negative growth rate & significant instability
1B: negative growth rate & non-significant instability
2A: positive growth rate & significant instability
2B: positive growth rate & non-significant instability
3A: non-significant growth rate & significant instability
3B: non-significant growth rate & non-significant instability

Only Bargarh district showing non-significant growth rate with significant instability index. There are 5 districts which showing non-significant growth rate and non-significant instability index. Remaining districts showing negative growth rate and non-significant instability index.

Table 4 shows the grouping of the districts of Odisha based on compound growth rate and instability index of production of kharif rice. 50% districts showing negative growth rate and non-significant instability index.

Table 5 shows the grouping of the districts of Odisha based on compound growth rate and instability index of yield of kharif rice. Most of the districts showing positive growth rate while the rest districts showing non-significant growth rate.

4. CONCLUSION

As the study has analyzed the growth rate and instability index of kharif rice in all districts of Odisha, which shows there are several fluctuations in the growth pattern of area, production and yield of rice in most of the districts. It is again revealed that the area under kharif rice have decreasing growth rate in all districts except in Malkangiri and Sonepur. However, the productivity of rice has shown wide variation across districts as well as Odisha. The varying performance of kharif rice at districts level has indicated the need for evolving specific strategies for ensuring sustainable and inclusive growth rate. 50% of districts showing higher growth rate in production as compare to Odisha.

The instability in area, production of kharif rice for the districts are higher than that of the state. This shows that though in individual districts the instability in area, yield and production is high but when considered for the entire state they result in comparatively more consistency.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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