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Analytical Study of Kharif Food Grain Production in Odisha

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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

The state of Odisha having an agrarian based economy depends largely on agriculture for the livelihood of its population. Food grains are important commodity of crop groups that provide high quality carbohydrates, protein and vitamins. A study on the compound growth rate of area, yield and production of food grains for kharif season in the districts of Odisha and the state as a whole has been attempted in the present study which would be helpful in visualizing the progress of the state with respect to food grain cultivation and proper framing of agricultural policies of the state. The study is based secondary data for the period of 1993-94 to 2017-18 to estimate the compound growth rate and Cuddy-Della Instability Index of area, yield and production of kharif food grains for the districts and the state as a whole. The districts are ranked on the basis of compound growth rate and Cuddy-Della Instability Index in decreasing order and increasing order of their magnitudes respectively. The rank correlation between Compound Growth Rate and Cuddy-Della Instability Index of area, yield and production of food grains during kharif seasons are studied. It is found that despite negative growth rate in area, the positive compound growth rate of yield leads to positive compound growth rate in production of kharif food grains of Odisha. Also it is found that despite stability of area, the instability of yield leads to instability in production of kharif food grains in the state of Odisha.

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1. INTRODUCTION

Agriculture is the backbone of the economy of Odisha. Food grains are the main determiner of the agricultural status of the state. The important cereals that are grown in Odisha are rice followed by ragi, wheat, bajra, small millets and wheat, The main pulse crops of Odisha are green gram, black gram, cowpea and arhar. The performance of food grains is affected by climatic factors mainly in Kharif season. As it has been mentioned earlier by Mehra [1] and Mitra [2] it has become very crucial to record and analyse the growth rate of crops in order to know the constraints of crop growth, technologies used to overcome the growth constraints, measures of the profits, losses, the reasons behind lower performance of a region or the better performance of a region etc. Dey [3] has linked the growth rate and instability and has said that the reason behind low growth rate can be high instability so in order to prove the main reason behind the lower performance of the crops during certain times many of the scientists started studying the growth rate, instability variability. With these perspectives in view, the Compound Growth Rate and Instability of area, yield and production of kharif food grains for all districts of Odisha and the state as a whole is done. The rank correlation between compound growth rate and instability index of area, yield and production of kharif food grains are also studied.

2. MATERIAL AND METHODS

Secondary data based on area, yield and production of kharif food grain are collected for all the districts of Odisha from 1993-94 to 2017-18 from various volumes of Odisha Agricultural Statistics published by Directorate of Agriculture and Food Production, Government of Odisha. Since the present 30 divided districts of the state has been formed in the year 1993 and the district wise agriculture data for the state is available till 2017-18 the period from 1993-94 to 2017-18 has been considered for the study.

The data on area, production and yield of the food grains in Odisha for the kharif season were worked out for the entire time period of analysis by fitting to exponential functions as follows:

$Xt= ab^t$

Where,

Xt= Area/ Production/ yield of food grain in years.
t = time element which takes the value 1, 2, 3, …, n
a = intercept
b = regression coefficient

The compound growth model is established in the following manner,

1n X t = 1n a + t 1n b
X t`= A` + B`t
Let 1n X t = X t`
1n a = A
1n b = B

The two generalized equations are

$$\sum_{t=1}^{n} X_t^l = \sum_{t=1}^{n} (A^l + B^l t)$$

$$\sum_{t=1}^{n} X_t^l = nA^l + B^l \sum_{t=1}^{n} t$$

$$\sum_{t=1}^{n} t\, X_t^l = A^l \sum_{t=1}^{n} t + B^l \sum_{t=1}^{n} t^2$$

Now by solving two equations and multiplying equation 1 with $\sum_{t=1}^{n}$ twe get,

$$\sum_{t=1}^{n} X_t^l \cdot \sum_{t=1}^{n} t = nA^l \sum_{t=1}^{n} t + B^l \left(\sum_{t=1}^{n} t\right)^2$$

By multiplying equation 2 with n on both sides we get,

$$n \sum_{t=1}^{n} t\, X_t^l = nA^l \sum_{t=1}^{n} t + nB^l \sum_{t=1}^{n} t^2$$

Equation 3 – Equation 4 we get,

$$n \sum_{t=1}^{n} tX_t^l - \sum_{t=1}^{n} X_t^l \cdot \sum_{t=1}^{n} t = nB^l \sum_{t=1}^{n} t^2 - B^l \left(\sum_{t=1}^{n} t\right)^2$$

$$n \sum_{t=1}^{n} tX_t^l - \sum_{t=1}^{n} X_t^l \cdot \sum_{t=1}^{n} t = nB^1 \sum_{t=1}^{n} t^2 - B^l \left(\sum_{t=1}^{n} t\right)^2$$

$$\Rightarrow \quad B' = \frac{\sum_{t=1}^{n} t\, X_t^l - \sum_{t=1}^{n} t \cdot \sum_{t=1}^{n} X_t^l}{\sum_{t=1}^{n} t^2 - \left(\sum_{t=1}^{n} t\right)^2}$$

Now, by putting the value of B' in equation 1 we get

$$\Rightarrow \quad A' = \left(\sum_{t=1}^{n} X_t^l \cdot B \sum_{t=1}^{n} t\right)/n$$

Given,

ln a= A' ; $a= e^{A'}$; ln b= B' ; $b= e^{B}$

Compound growth rate (C. G. R) = (b-1) × 100
SE (C. G. R) = ln b × (ln b/ ln10) [4]

Cuddy- Della Instability Index is used as a measure of Instability as its adjust the Coefficient of variation for trend.

Cuddy- Della Instability Index is represented as (CDII) and given as,

$$CDII = CV \times \sqrt{1 - R^2} \quad [5]$$

Where,

CV= Coefficient of Variation = $\frac{\sigma}{\bar{x}} \times 100$
σ = Standard deviation of Mean Area/Yield/Production
$\bar{x}$ = Mean of Area/Yield/Production

R^2 = Coefficient of determination from the time trend regression adjusted for its degree of freedom Spearman's formulae for correlation coefficient,

$$r_c = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(n^2-1)} \quad [6]$$

Where,

di = difference between two ranks of each observation
n = number of observations
H_0: ρ=0
H: ρ≠ 0

Where, ρ is the population rank correlation coefficient.

$$t_{cal} = \sqrt{\frac{1-r_c^2}{n-2}} \quad [7]$$

$|t_{cal}|$ is calculated by $t_{\alpha/2}$ n-2 obtained from t table.

If $|t_{cal}| > t_{\alpha/2}$, n-2 then H_0 is rejected.

Otherwise H_0 is accepted.

3. RESULTS AND DISCUSSION

Table 1 presents the Compound Growth Rate of area, yield and production for kharif food grains in different districts of Odisha**.** The study of the table reveals that for the state, there is negative growth rate in area and positive growth rate in case of yield and production of kharif food grains. Despite negative growth rate in area, the positive compound growth rate of yield leads to positive compound growth rate in production of kharif food grains of Odisha.

Fig. 1, shows the graphical presentation of compound growth rate of area, yield and production of kharif food grains for different districts of Odisha. The study of the figure reveals that compound growth rate of area is found to be negative for most of the districts and is positive only for few districts like Bargarh, Deogarh, Gajapati, Malkangiri, Nabarangpur, and Nuapada. The compound growth rate of yield is positive for all the districts except for Bargarh and Sambalpur. The compound growth rate of production is positive except for Bargarh which is due to the negative growth rate of yield in Bargarh.

Table 2 depicts the Cuddy- Della Instability Index of area, yield and production for kharif food grains in different districts of Odisha**.** The study of the table 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 in production.

Fig. 2, shows the graphical presentation of cuddy-Della instability index of area, yield and production of kharif food grains for different districts of Odisha. The study of the figure reveals that instability of area it is found to be low for most of the districts except for few like Malkangiri, Jharsuguda and Jajpur. The instability of yield and production is seen to be high.

In Table 3 the districts are ranked on the basis of compound growth rate and Cuddy-Della Instability Index in decreasing order and increasing order of their magnitudes respectively. for area, yield and production of kharif food grains. It is found from the table that in case of compound growth rate of area under kharif food grains the district with highest rank is Sonepur followed by Nuapada and Gajapati. Similarly the districts with lowest rank is Dhenkanal followed by Puri and Kandhamal. On basis of cuddy-della instability index for area under kharif food grains the highest rank is for Sundargarh followed by Bargarh and Bhadrak district, whereas, the district with lowest rank is Malkangiri followed by Jharsuguda and Jajpur. In case of compound growth rate o f yield under kharif food grains the district with highest rank is Jagatsinghpur

followed by Nabrangpur and Kalahandi. Similarly the districts with lowest rank is Bargarh followed by Sambalpur and Nayagarh. On basis of cuddy-della instability index the highest rank is for Koraput followed by Kandhmal and Rayagada district, whereas, the district with lowest rank is Bolangir followed by Deogarh and Jharsuguda. In case of compound growth rate of production of kharif food grains the district with highest rank is Nabrangpur followed by Sonepur and Kalahandi. Similarly the districts with lowest rank is Bargarh followed by Jharsuguda and Sambalpur. On basis of cuddy-della instability index the highest rank is for Koraput followed by Kandhamal and Gajapati district, whereas, the district with lowest rank is Bolangir followed by Deogarh and Sonepur.

Table 4 shows that rank correlation coefficient between compound growth rate and Cuddy-Della Instability Index area, yield and production of kharif food grains in Odisha is insignificant in all cases.

Table 1. Compound Growth Rate of area, yield and production for khairf food grains in different districts of Odisha (*in percent*)

Sl. No.	Districts	Area	Yield	Production	Sl. No	Districts	Area	Yield	Production
1	Anugul	-0.432	1.929	1.488	16	Kandhamal	-1.476	1.917	0.412
2	Balasore	-1.038	2.723	1.657	17	Kendrapada	-0.508	1.889	1.371
3	Bargarh	0.208	-0.262	-0.054	18	Keonjhar	-0.574	2.936	2.345
4	Bhadrak	-0.335	2.273	1.931	19	Khurda	-1.097	1.860	0.742
5	Bolangir	-0.247	3.078	2.823	20	Koraput	-0.566	2.369	1.789
6	Boudh	0.083	2.836	2.922	21	Malkangiri	0.452	1.925	2.387
7	Cuttack	-1.051	2.901	1.819	22	Mayurbhanj	-0.406	2.043	1.628
8	Deogarh	0.372	2.208	2.588	23	Nabarangpur	0.373	3.427	3.814
9	Dhenkanal	-1.907	3.187	1.219	24	Nayagarh	-0.132	0.522	0.389
10	Gajapati	0.496	0.677	1.177	25	Nuapada	0.543	2.280	2.836
11	Ganjam	-0.379	0.992	0.609	26	Puri	-1.721	2.523	0.758
12	Jagatsinghpur	-1.297	4.158	2.807	27	Rayagada	-0.087	2.604	2.514
13	Jajpur	-0.946	1.791	0.828	28	Sambalpur	0.336	-0.196	0.139
14	Jharsuguda	-0.704	0.811	0.101	29	Sonepur	0.722	2.442	3.182
15	Kalahandi	-0.270	3.372	3.092	30	Sundargarh	-0.619	3.266	2.626
	Odisha	**-0.392**	**2.271**	**1.870**					

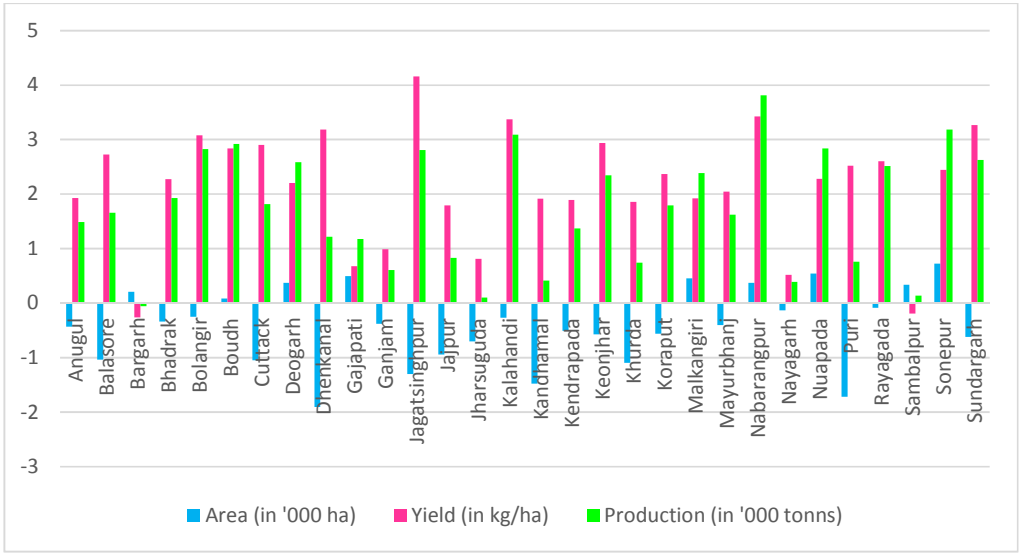

Fig. 1. Compound growth rate of Area, Yield and Production of kharif food grains for all districts of Odisha

Table 2. Cuddy-Della instability index of area, yield and production of kharif food grains for all districts of Odisha and the state as a whole (*in percent*)

Sl.no	District	Area	Yield	Production	Sl.no	District	Area	Yield	Production
1	Anugul	6.502	33.83	34.14	16	Kandhamal	7.340	15.45	17.84
2	Balasore	5.487	28.01	27.64	17	Kendrapada	5.615	23.57	24.88
3	Bargarh	3.215	30.76	30.96	18	Keonjhar	4.535	23.51	23.75
4	Bhadrak	3.846	25.03	24.76	19	Khurda	6.309	30.44	29.56
5	Bolangir	5.134	48.49	49.48	20	Koraput	4.496	14.75	17.11
6	Boudh	6.914	34.77	35.22	21	Malkangiri	15.66	25.58	25.58
7	Cuttack	5.669	29.60	28.17	22	Mayurbhanj	3.950	23.39	24.38
8	Deogarh	6.761	38.04	40.68	23	Nabarangpur	6.688	25.01	26.23
9	Dhenkanal	7.537	33.33	33.08	24	Nayagarh	3.919	33.30	33.55
10	Gajapati	7.093	18.09	18.81	25	Nuapada	4.239	35.16	37.15
11	Ganjam	6.080	32.81	34.85	26	Puri	7.621	34.49	31.05
12	Jagatsinghpur	5.861	30.62	27.63	27	Rayagada	8.515	17.22	21.84
13	Jajpur	8.996	29.97	29.86	28	Sambalpur	5.646	31.78	32.84
14	Jharsuguda	10.69	36.08	37.20	29	Sonepur	5.581	29.74	33.43
15	Kalahandi	7.857	31.10	31.35	30	Sundargarh	3.143	33.71	32.51
	Odisha	**2.687**	**19.79**	**20.42**					

Table 3. Rank of the districts on basis of Compound Growth Rate (CGR) and Cuddy-Della Instability Index (CDII) of area, yield and production of kharif food grains

Sl No.	Districts	Area		Yield		Production		Sl No.	Districts	Area		Rabi		Production	
		CGR	CDII	CGR	CDII	CGR	CDII			CGR	CDII	CGR	CDII	CGR	CDII
1	Anugul	17	18	19	24	18	24	16	Kandhamal	28	23	21	2	26	2
2	Balasore	24	10	10	11	16	12	17	Kendrapada	18	12	22	7	19	8
3	Bargarh	8	2	30	17	30	16	18	Keonjhar	20	8	7	6	12	5
4	Bhadrak	14	3	16	9	13	7	19	Khurda	26	17	23	15	24	14
5	Bolangir	12	9	6	30	6	30	20	Koraput	19	7	14	1	15	1
6	Boudh	9	21	9	26	4	26	21	Malkangir	4	30	20	10	11	9
7	Cuttack	25	14	8	12	14	13	22	Mayurbhanj	16	5	18	5	17	6
8	Deogarh	6	20	17	29	9	29	23	Nabarangpur	5	19	2	8	1	10
9	Dhenkanal	30	24	5	22	20	21	24	Nayagarh	11	4	28	21	27	23
10	Gajapati	3	22	27	4	21	3	25	Nuapada	2	6	15	27	5	27
11	Ganjam	15	16	25	20	25	25	26	Puri	29	25	12	25	23	17
12	Jagatsinghpur	27	15	1	16	7	11	27	Rayagada	10	27	11	3	10	4
13	Jajpur	23	28	24	14	22	15	28	Sambalpur	7	13	29	19	28	20
14	Jharsuguda	22	29	26	28	29	28	29	Sonepur	1	11	13	13	2	22
15	Kalahandi	13	26	3	18	3	18	30	Sundargarh	21	1	4	23	8	19

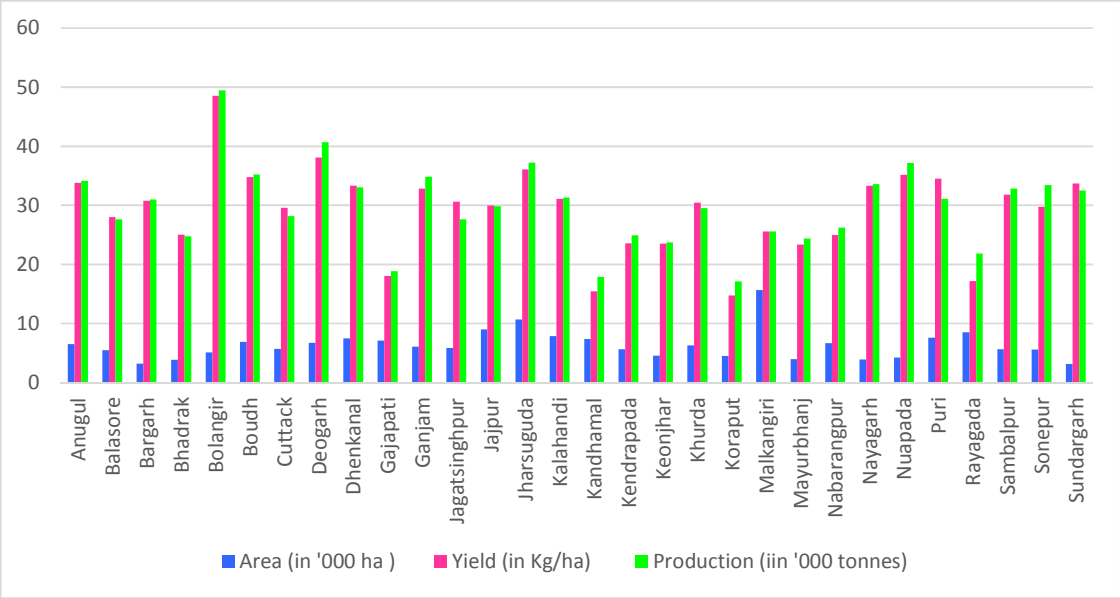

Fig. 2. Cuddy-Della instability index of area, yield and production of kharif food grains for different districts od Odisha

Table 4. Association and comparison between CGR and CDII of area, yield and production of kharif food grains in different districts of Odisha

	Area	Yield	Production
Rank Correlation Coefficient (ρ)	-0.060	-0.040	0.005
SE (standard error)	0.188	0.188	0.188
abs(t-value)	0.319	0.215	0.029
p-value	0.751	0.830	0.976

4. SUMMARY AND CONCLUSION

The compound growth rate in case of area, yield and production under kharif food grains is found to be higher than that of the state in the districts like Boudh, Kalahandi, Nuapada, Nabarangpur and Sonepur. Thus these districts show better performance than the average performance of the state with respect to compound growth rate of area, yield and production. The district of Dhenkanal shows poor performance with respect to area, yield and production by having lower growth rate than that of state. The instability of the districts in case of area, yield and production under kharif food grains is found to be lower than that of the state for Gajapati, Kandhamal and Koraput. Thus these districts show better performance than the average performance of the state with respect to instability of area, yield and production of kharif food grains. The district found to perform poorly is Bolangir which has higher instability than that of the state. Rank Correlation Coefficient between CGR and CDII of area, yield and production under kharif and rabi food grains of Odisha show that the rank correlation is found to be positive and insignificant in area, yield and production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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