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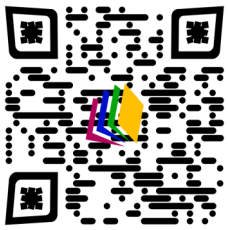

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Analytical Study of Maize Production in Western Odisha

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ABSTRACT:

Agriculture development in India has undergone many changes over the years. The changes especially in the last one decade are attributable to multiplicity of factors. Agriculture sector in Odisha is prone to high risk and uncertainties which in turn make it necessary to assess the magnitude of growth as well as instability. In the present study an attempt has been made on area, yield and production to estimate the compound growth rate and instability of maize for both the seasons kharif and rabi. The study used secondary data for the period of 1993 -94 to 2015-16. Twenty three years data have been taken to estimate the compound growth rate and coppock's instability index and ranking the districts of Western Odisha on the basis of compound growth rate and coppock's instability index in decreasing order of their magnitudes. The compound growth rate and instability of the area, production and yield of the maize for kharif and rabi season in the districts of western odisha are studied. The districts of Western Odisha are also ranked according to the growth rate and instability of maize crop. Coppock's Instability Index is used as a measure of instability. The area, yield and production of maize showed a positive compound growth rate in both kharif and rabi season in Odisha.

KEY WORDS: Compound growth rate Coppock's Instability Index, Instability, Maize, Production.

Cereal crops are primarily grown for various edible purposes. Cereals are grown in greater quantities and provide more food energy worldwide than any other type of crop and are therefore staple crops. Cereals are a rich source of vitamins, minerals, carbohydrates, fats, oils, and protein. Western Odisha is a territory in western part of Odisha, India, extending from district in the south to the Sundergarh district in the north-west. Western Odisha includes the districts of Sambalpur, Sundergarh, Kalahandi, Bargarh, Nuapada, Balangir, Sonepur, Deogarh and Jharsuguda. The most commonly known cereal crops grown are rice, wheat, maize and ragi. The study aims at examining the comparison between compound growth

rate and instability of maize crop in the districts of western odisha as well as for the state as a whole and to classify the districts of western odisha according to the compound growth rate and instability of maize crop.

Dash, et al. (2017) studied the growth rate and instability of area, yield and production of food grain in Odisha using the best fit model and the model selected on the basis of scatter plot of the data. Kachroo *et al*. (2013) studied the growth and instability of maize in Jammu and Kashmir. It was observed that there was positive and significant growth trend in production as well as yield of maize in India. Dhakre and Sharma, (2010) stated that maximum increase in production and productivity of maize crop in Nagaland was 103.05 percent in the year 1988-89 and 101.26 per cent in the 1988-89 respectively. Among area, production and productivity of maize the instability was highest for the production.

MATERIALS AND METHODS

The study regarding area, production and yield of maize in the districts of Western Odisha for both kharif and rabi seasons is done for the period 1993-94 to 2015-16. The study is based on the secondary source of data on area, production and yield of Maize in both kharif and rabi seasons for the period 1993-94 to 2015-16 obtained from various volumes of Odisha Agriculture Statistics published by the Directorate of Agriculture and Food Production, Government of Odisha.

Compound growth rate (CGR):-

The data on area, production and yield of major cereal crops were worked out for entire period of analysis by fitting to exponential function as follows.

$Y_t = ab^{t}$--

Where, Y_t =Area/Production/Yield of major cereal crops 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

$\log Y_t = \text{Log } a + t \text{Log } b$

$Y_t' = A' + B't$

Let $\text{Log } Y_t = Y_t'$,

$\text{Log } a = A'$

$\text{Log } b = B'$

The two generalised equations are

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

$$\Rightarrow \sum_{t=1}^{n} Y_t' = nA' + B' \sum_{t=1}^{n} t$$

. . . equation 1

$$\sum_{t=1}^{n} tY_t' = A' \sum_{t=1}^{n} t + B' \sum_{t=1}^{n} t^2$$

. . . equation 2

Solving the 2 equations and multiplying equation 1 by $\sum_{t=1}^{n} t$ on both sides we get

$$\sum_{t=1}^{n} Y_t' . \sum_{t=1}^{n} t = nA' \sum_{t=1}^{n} t + B' \left(\sum_{t=1}^{n} t \right)^2$$

. . .equation 3

Multiplying equation 2 by n on both sides we get

$$n \sum_{t=1}^{n} tY_t' = nA' \sum_{t=1}^{n} t + nB' \sum_{t=1}^{n} t^2$$

. . .equation 4

equation 4 – equation 3 we get

$$n \sum_{t=1}^{n} tY_t' - \sum_{t=1}^{n} Y_t' . \sum_{t=1}^{n} t = nB' \sum_{t=1}^{n} t^2 - B' \left(\sum_{t=1}^{n} t \right)^2$$

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

$\Rightarrow$

Putting the value of B' in equation 1 we get

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

Given, Log a=A; a=Antilog A; Log b=B'; b=Antilog B'

Compound Growth Rate (C.G.R) =(antilog B' -1) x100

Coppock's Instability Index (CII) = Antilog $\left(\sqrt{v\log} - 1\right) \times 100$

Where, V log= $\left(\sum \log \frac{X_{t+1}}{X_t} - m\right)^2$

RESULTS AND DISCUSSION

The study of the Table 1 indicates that the area of maize showed a positive compound growth rate in kharif season in Odisha and in all the districts of Western Odisha during the study period (1993-94 to 2015-16). The highest compound growth rate of kharif maize area in Western Odisha was observed in the district of Kalahandi which is 1.558 per cent per annum and the lowest in Sundargarh which is 0.226 per cent per annum. The variability in area of kharif maize in Western Odisha and that of the state of Odisha during the study period was determined through coppocks instability index, and the results are presented in Table 1. The variability in area under kharif maize cultivation in the state was found to be 10.653 per cent during overall period of study. During the study period the variability in area under kharif maize was highest in the Sonepur district of Western Odisha which is 15.845 per cent and the lowest variability was seen in the district of Sundargarh which is 11.103. The higher variability in area under kharif maize production may be due to the variability in rainfall.

Table 1 which also reveals that the area under maize registered positive compound growth rate in rabi season in the state of Odisha and also in the districts of Western Odisha. During the study period, area under maize crop in rabi season in the state shows a compound growth rate of 0.972 per cent per annum. The highest compound growth of maize area in Western Odisha was observed in the district of Kalahandi which is 2.336 per cent per annum and the lowest in district of Sonepur which is 0.469 per cent per annum. The variability in area of rabi maize in Western Odisha and that of the state of Odisha in rabi season during overall study period of was determined through coppock's instability index, and the results are presented in Table 1.

The variability in area of rabi maize cultivation in the state was estimated to be 12.139 per cent during overall period of study. During the study period the variability in area under rabi maize was highest in the Nuapada district of Western Odisha of 18.167 per cent. This higher variability in area under rabi maize production may be due to the variability in rainfall or other climatic factors.

Table 1: Compound Growth Rate and Coppock's Instability Index for area of maize in kharif and rabi seasons for the districts of western Odisha and the state as a whole. (in per cent)

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**

In case of yield of maize during kharif season, the study of the Table 2 indicates that the yield of maize showed a positive compound growth rate in kharif season in Odisha and in all the districts of Western Odisha during the study period (1993-94 to 2015-16). The highest compound growth of kharif maize yield in Western Odisha was observed in the district of Kalahandi which is 1.749 per cent per annum and the lowest in Bargarh which is 0.372 per cent per annum.

The district Bargarh showed the minimal compound growth rate followed by the district of Sundargarh and Sambalpur respectively. The variability in yield of kharif maize in Western Odisha and that of the state of Odisha during the study period was determined through coppocks instability index, and the results are presented in Table 1. The variability in yield under kharif maize cultivation in the state was found to be 11.213 per cent during overall period of study. During the study period the variability in yield under kharif maize was highest in the Bargarh district of Western Odisha which is 13.878 per cent and the lowest variability was seen in the district of Sonepur which is 11.642. The higher variability in yield under kharif maize production may be due to the variability in rainfall.

In case of yield of maize during rabi season, Table 2 reveals that the yield under maize registered positive compound growth rate in rabi season in the state of Odisha and also in the districts of Western Odisha. During the study period, yield under maize crop in rabi season in the state shows a compound growth rate of 1.277 per cent per annum. The highest compound growth of maize yield in Western Odisha was observed in the district of Kalahandi which is 1.697 per cent per annum and the lowest in district of Bargarh which is 0.124 per cent per annum. The variability in yield of maize in Western Odisha and that of the state of Odisha in rabi season during overall study period was determined through coppock's instability index, and the results are presented in Table 2. The variability in yield of rabi maize in the state was estimated to be 11.374 per cent during overall period of study. During the study period the variability in yield under rabi maize was highest in the Sundargarh district of Western Odisha of 14.101 per cent. This higher variability in yield under rabi maize production may be due to the variability in rainfall or other climatic factors.

Table 2: Compound Growth Rate and Coppock's Instability Index for yield of maize in kharif and rabi seasons for the districts of western Odisha and the state as a whole. (in per cent)

Districts	Kharif		Rabi	
	CGR	CII	CGR	CII
Balangir	14.603	12.333	1.298	12.156
Bargarh	0.372	13.878	0.124	11.579
Deogarh	0.473	12.102	0.303	12.228
Jharsuguda	0.646	13.626	0.184	11.402
Kalahandi	1.749	12.076	1.697	12.757
Nuapada	0.938	13.501	1.076	12.619
Sambalpur	0.451	12.991	0.322	11.957
Sonepur	1.251	11.642	1.201	11.227
Sundargarh	0.416	12.607	0.614	14.101
Odisha	**1.011**	**11.213**	**1.277**	**11.374**

In case of production of maize during kharif season, the study of the Table 3 indicates that the production of maize showed a positive compound growth rate in kharif season in Odisha and in all the districts of Western Odisha during the study period. The highest compound growth of kharif maize production in Western Odisha was observed in the district of Kalahandi which is 3.334 per cent per annum and the lowest in Sundargarh which is 0.644 per cent per annum. The variability in production of kharif maize

in Western Odisha and that of the state of Odisha during the study period was determined through coppocks instability index, and the results are presented in Table 2. The variability in production under kharif maize cultivation in the state was found to be 11.509 per cent during overall period of study. During the study period the variability in production under kharif maize was highest in the Sonepur district of Western Odisha which is 15.908 per cent and the lowest variability was seen in the district of Balangir which is 13.226 per cent. The higher variability in production under kharif maize production may be due to the variability in rainfall.

In case of yield of maize during rabi season, Table 3 also reveals that the production under maize registered positive compound growth rate in rabi season in the state of Odisha and also in the districts of Western Odisha except for the district of Deogarh which showed a negative compound growth rate. During the study period, production under maize crop in rabi season in the state shows a compound growth rate of 2.262 per cent per annum. The highest compound growth of rabi maize production in Western Odisha was observed in the district of Kalahandi which is 4.090 per cent per annum and the lowest in district of Deogarh which is 0.304 per cent per annum. The variability in production of maize in Western Odisha and that of the state of Odisha in rabi season during overall study period was determined through coppock's instability index, and the results are presented in Table 3. The variability in production of rabi maize cultivation in the state was estimated to be 13.063 per cent during overall period of study. During the study period the variability in production of rabi maize was highest in the Kalahandi district of Western Odisha which is 19.135 per cent. This higher variability in production under rabi maize production may be due to the variability in rainfall or other climatic factors.

Table 3: Compound Growth Rate and Coppock's Instability Index for production of maize in kharif and rabi seasons for the districts of western Odisha and the state as a whole

(in per cent)

Districts	Kharif		Rabi	
	CGR	CII	CGR	CII
Balangir	2.259	13.226	2.022	14.905
Bargarh	1.266	15.226	1.139	14.075
Deogarh	1.406	13.735	-0.304	14.768
Jharsuguda	2.200	15.817	0.680	16.470
Kalahandi	3.334	13.345	4.090	19.135
Nuapada	2.390	13.799	3.188	18.838
Sambalpur	1.955	14.996	1.908	16.546
Sonepur	2.013	15.908	1.662	15.930
Sundargarh	0.644	13.378	1.104	15.671
Odisha	**1.733**	**11.510**	**2.262**	**13.063**

The table 4 shows that the Kalahandi district shows highest rank (rank 1) with respect to compound growth rate of area under kharif maize and rabi maize and also with respect to coppocks instability index it is ranked 4 and 5 in kharif and rabi season respectively which shows that the district gives good performance in area under maize crop in both kharif and rabi season but it is not stable. But in case of Nuapada the rank with respect to compound growth rate in area under rabi maize is rank 2 and with respect to coppock's instability index its rank is 1 which shows that there is highly unstable performance in this district. The district Jharsuguda shows highly instability in both the seasons which shows that the area under maize crop in this district is much unstable.

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 maize in kharif and rabi seasons .

Districts	Kharif		Rabi	
	Rank of the districts according to Compound Growth Rate (In decreasing order of magnitude)	Rank of the districts according to Coppock's Instability Index (In decreasing order of magnitude)	Rank of the districts according to Compound Growth Rate (In decreasing order of magnitude)	Rank of the districts according to Coppock's Instability Index (In decreasing order of magnitude)
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

The study of Table 5 shows the ranking of the districts on the basis of compound growth rate and coppock's instability index of yield of maize. With the different rankings the districts are classified on the basis of their performance. The Table 5 shows that in kharif season the rank of the District of Balangir with the respect to compound growth rate of yield of maize is the highest (rank 1) but with respect to coppock's instability index it is low (rank 6) which shows that the district gives good performance in yield under maize crop in kharif season. But in case of Bargarh the rank with respect to compound growth it is the opposite which shows that it is highly unstable and there is very less or minimal compound growth rate in yield. In rabi season the rank of the District of Kalahandi with the respect to compound growth rate of yield under maize is the highest (rank 1) and also with respect to coppock's instability index it is ranked 2 which shows that the district gives good performance in yield of maize crop in rabi season but it is not stable. But in case of Sundargarh the rank with respect to compound growth is rank 5 and with respect to coppock's instability index its rank is 1 which shows that there is highly unstable performance in this district. The district Sonepur shows highly instability in both the seasons which shows that the yield under maize crop in this district is much unstable.

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 yield under maize in kharif and rabi seasons .

Districts	Kharif		Rabi	
	Rank of the districts according to Compound Growth Rate (In decreasing order of magnitude)	Rank of the districts according to Coppock's Instability Index (In decreasing order of magnitude)	Rank of the districts according to Compound Growth Rate (In decreasing order of magnitude)	Rank of the districts according to Coppock's Instability Index (In decreasing order of magnitude)
Balangir	1	6	2	5
Bargarh	9	1	9	7
Deogarh	6	7	7	4
Jharsuguda	5	2	8	8
Kalahandi	2	8	1	2
Nuapada	4	3	4	3
Sambalpur	7	4	6	6
Sonepur	3	9	3	9
Sundargarh	8	5	5	1

The table 6 shows that in kharif season the rank of the District of Kalahandi with the respect to compound growth rate of production of maize is the highest (rank 1) and also with respect to coppock's instability index it is ranked 9 which shows that the district gives good performance in production under maize crop in kharif season which is also very stable. But in case of Balangir the rank with respect to compound growth is rank 3 and with respect to coppock's instability index its rank is 8 which shows that there is highly stable performance in this district. The district Sonepur shows highly instability in kharif season which shows that the production under maize crop in this district is much unstable. In rabi season the rank of the District of Kalahandi with the respect to compound growth rate of production of maize is the highest (rank 1) and also with respect to coppock's instability index it is ranked 1 which shows that the district gives unstable performance in production of maize crop in rabi season. But in case

of Deogarh the rank with respect to compound growth is rank 9 and with respect to coppocks instability index its rank is 9 which shows that there is highly stable performance in this district though having low growth rate.

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 production under maize in kharif and rabi seasons.

Districts	Kharif		Rabi	
	Rank of the districts according to Compound Growth Rate (In decreasing order of magnitude)	Rank of the districts according to Coppock's Instability Index (In decreasing order of magnitude)	Rank of the districts according to Compound Growth Rate (In decreasing order of magnitude)	Rank of the districts according to Coppock's Instability Index (In decreasing order of magnitude)
Balangir	3	8	3	7
Bargarh	8	3	6	8
Deogarh	7	6	9	9
Jharsuguda	4	2	8	4
Kalahandi	1	9	1	1
Nuapada	2	5	2	2
Sambalpur	6	4	4	3
Sonepur	5	1	5	5
Sundargarh	9	7	7	6

Summary and Conclusion

The area of maize showed a positive compound growth rate in kharif season in Odisha and in all the districts of Western Odisha during the study period. The area under maize crop in rabi season in the state shows a compound growth rate of 0.972 per cent per annum. The yield of maize showed a positive compound growth rate in kharif season in Odisha and in all the districts of Western Odisha during the study period. The yield under maize registered positive compound growth rate in rabi season in the state of Odisha and also in the districts of Western Odisha. The production of maize showed a positive compound growth rate in kharif season in Odisha and in all the districts of Western Odisha during the study period. The production under maize registered positive compound growth rate in rabi season in the state of Odisha and also in the districts of Western Odisha except for the district of Deogarh which showed a negative compound growth rate. The variability in area under maize cultivation during kharif season in the state was found to be 10.653 per cent during overall period of study. The variability in area of rabi maize cultivation in the state was estimated to be 12.139 per cent during overall period of study. The variability in kharif season yield under maize cultivation in the state was found to be 11.213 per cent during overall period of study. The variability in yield of rabi maize cultivation in the state was estimated to be 11.374 per cent during overall period of study. The variability in production under kharif maize cultivation in the state was found to be 11.509 per cent during overall period of study. The variability in production of rabi maize cultivation in the state was estimated to be 13.063 per cent during overall period of study. This higher variability in production under maize production may be due to the variability in rainfall or other climatic factors. Kalahandi district shows very good performance with respect to area under maize during kharif and rabi season. Balangir shows very good performance with respect to yield of maize during kharif season. Kalahandi district shows very good performance with respect to production of maize during kharif season. The district Sonepur shows highly instability in both the seasons which shows that the yield under maize crop in this district is much unstable. From the study it can be concluded that most of the districts of Western Odisha which shows good performance with respect to compound growth rate of area, yield and production of maize in both kharif and rabi season performs very poorly with respect to stability.

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