Statistical Analysis of Growth and Instability of Rabi Food Grain Production in Coastal Districts of Odisha, India

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Authors’ contributions

This work was carried out in collaboration among all authors. Authors AD and PP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author SKM managed the analyses of the study. Author PM managed the literature searches. All authors read and approved the final manuscript.

ABSTRACT

Agriculture is the backbone of the economy of Odisha, India. Food grain production in the state is mainly confined in the coastal areas. Coastal land, one of the important production systems occupying an area of about 10.78 million ha, has a significant contribution to the food grain production of the state. Food grains include both cereals and pulses. To study the variation in production of Rabi food grains, a study is made about the area and yield of rabi food grains in these coastal districts from the year 1993-94 to 2014-15. For this purpose, the whole period of study (1993-94 to 2014-15) is divided into two sub-periods i.e. Period-I (1993-94 to 2002-03) and Period-II (2003-04 to 2014-15) on the basis of scatter plot of area, yield and production of Rabi food grains of Odisha. The Indian cropping season is classified into two main seasons-(i) Kharif and (ii) Rabi based on the monsoon. This study includes test of significance of change in mean and variance of area, yield and production of Rabi food grains from Period-I to Period-II. To test the significance of change in mean and variance of area, yield and production of rabi food grains from
Period-I to Period-II, Fisher's t-test and Snedecor's F-test have been used respectively. No significant change in mean area from Period-I to Period-II was found but there is high variation in mean yield and mean production of *Rabi* food grains. High variation in mean yield and mean production of *Rabi* food grains is marked which may be due to uneven spread of technologies. The results of the study revealed that the variability (variance) in production of *Rabi* food grains of Odisha increased from Period-I to Period-II. Change in coefficient of variation of area, yield and production of *Rabi* food grains show significant decrease from Period-I to Period-II.

**Keywords:** Food grains; production; scatter plot; mean; variance and coefficient of variation.

### 1. INTRODUCTION

Agriculture is the chief occupation in Odisha. About 76% of the total working population is engaged with agriculture related industries. The total cropped area in Odisha is 87,46,000 ha and out of that 18,79,000 ha are under irrigation. The principal problem that Odisha agriculture faces is the shortage of water in many areas. Lack of irrigation facilities in these droughts prone areas create great obstacles to the agriculture. The entire rabi area is irrigated and covered by hybrid paddy where as 36% of kharif area paddy area is covered under irrigation. The percentage of area under kharif and rabi food grains in coastal Odisha are 24.65% and 39.57% of the total area of the state respectively. Likewise in case of production, coastal Odisha contributes 24.41% and 31.77% in kharif and rabi seasons respectively. In case of kharif and rabi cereals, coastal Odisha contributes 27.72% and 25.89% in area and 25.14% and 24.80% in production respectively as compared to the whole state. The percentage of area and production in kharif and rabi seasons of coastal Odisha are 6.09 %, 42.91 % and 6.72 %, 43.21 % as compared to the area and production of whole state. Variability in production of food grains arises due to the deceleration in the trend growth rate of food grains production over time after the initial phase of green revolution and due to regional disparities in agricultural development which is primarily due to uneven spread of new agricultural technologies. The food grain production variance in coastal districts of Odisha is expected to change after a decade. So to study any possible change in production, the entire period of study would be divided into at least two periods on some statistical basis. The changes in the cropping pattern are generally viewed as a shift from traditionally-grown less-remunerative crops to more-remunerative crops [1]. During Green Revolution period, there was a continuous surge for diversifying agriculture in terms of crops, primarily on economic considerations [2,3]. Krishnaji [4] observed the inequalities in inter-state and inter-districts per capita food grains production and productivity in India during 1950-53, 1960-63 and 1970-73. Mishra et al. [5] considered ARIMA model on fertilizer statistics for India forecasted for 2020. Mishra et al. [6] & Sahu and Mishra [7] studied the instability of food grain and maize in India respectively and used ARIMA models for forecasting. Tripathy et al. [8] studied growth rate of the inter-district disparities in agriculture of odisha covering the period 1980-81 to 1992-93. Reddy [9] studied regional disparities in agricultural growth in coastal plains and central Table Zones of Odisha from pre-liberalization (1971-90) to post-liberalization (19991-2008) periods. Kumar et al. [10] studied the inter-district disparities in agricultural performance in Haryana over three periods i.e. 1990, during 1990-2002 and 2002-09.

Keeping in view of the above perspectives, the study has become made with the following objectives:

1. To find out a break point in the whole period of study with respect to area, yield and production of food grains in Odisha for rabi seasons on basis of scatter plot of the data and then accordingly divide the entire period of study into two periods i.e. Period-I and Period-II.
2. To test the significance of change in mean and variance of area, yield and production of food grains from Period-I to Period-II for rabi seasons in coastal districts of Odisha and the state.

### 2. MATERIALS AND METHODS

The study is based on the secondary source of data on area, production and yield of food grains in the coastal districts of Odisha for rabi seasons for the period 1993-94 to 2014-15. The data are obtained from various volumes of Odisha Agriculture Statistics published by the Directorate of Agriculture and Food Production, Government of Odisha.
To find the mean area/production/yield of both the periods of study the following formula is used. For a sample \( x_1, x_2, \ldots, x_n \) of \( n \) observations, the mean, 

\[
\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}
\]

Fisher’s t-test was used to test whether two independent sample means are significantly different or not. It is used for testing the significance of difference between the mean area/yield/production of two periods.

To test this we take random samples of sizes \( n_1 \) and \( n_2 \) from the two populations.

Null hypothesis, \( H_0: \mu_1 = \mu_2 \) i.e. the two population means are identical.

a) Alternative hypothesis, \( H_1: \mu_1 \neq \mu_2 \) (two tailed test)
   We find the two sample means \( \bar{x}_1 \) and \( \bar{x}_2 \) to draw conclusions about \( \mu_1 \) and \( \mu_2 \).

b) Level of significance (\( \alpha \)) is generally fixed at 5% or 1%.

c) Test statistic,

\[
t = \frac{\left( \bar{x}_1 - \bar{x}_2 \right)}{S_2 \left[ \left( \frac{1}{n_1} \right) + \left( \frac{1}{n_2} \right) \right]^{1/2}}
\]

Here, \( S_2^2 \) is pooled variance and is given by:

\[
S_2^2 = \frac{\sum_{i=1}^{n_1} (x_{1i} - \bar{x}_1)^2 + \sum_{i=1}^{n_2} (x_{2i} - \bar{x}_2)^2}{(n_1 + n_2 - 2)}
\]

\[
\bar{x}_1 = \frac{\sum_{i=1}^{n_1} x_{1i}}{n_1}, \quad \bar{x}_2 = \frac{\sum_{i=1}^{n_2} x_{2i}}{n_2}
\]

a) From the t-table, the critical value of \( t \) is obtained for \( (n_1 + n_2 - 2) \) degrees of freedom at 0.05% and 0.01% level of significance.

b) Tabulated \( t \) values are found for 0.05% and 0.01% level of significance at \( (n_1 + n_2 - 2) \) degrees of freedom.

c) Let the \( t_{cal} \) for 0.05% and 0.01% level of significance be represented by \( t_1 \) and \( t_2 \) respectively.

d) If \( t_{cal} > t_2 \), then we reject the null hypothesis at 1% level of significance. Here \( t \) is considered to be highly significant and mean of two periods differ significantly at 1% level of significance.

e) If \( t_{cal} < t_1 \), we accept null hypothesis. Here \( t \) is considered to be in-significant and we conclude that mean of two period don’t differ significantly.

f) If \( t_{cal} < t_0 \), then we reject the null hypothesis only at 5% level of significance. Here \( t \) is considered to be significant and we conclude that mean of two periods differ significantly at 5% level of significance.

To find the variance (\( \sigma^2 \)) of area/production/yield of both the periods of study the following formula is used: Variance,

\[
\sigma^2 = \frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n}
\]

Test of significance of difference in the sample variances of area/yield/production for two different periods is done by Snedecor’s F-test.

It is a statistical test used to compare two variances. The test procedure is as follows:

Null hypothesis; \( H_0: \sigma_1^2 = \sigma_2^2 \) (where \( \sigma_1^2 \) and \( \sigma_2^2 \) are the two population variances)

Alternative hypothesis; \( H_1: \sigma_1^2 \neq \sigma_2^2 \) (two-tailed test)

Level of significance, \( \alpha = 0.05 \) (5%) or 0.01(1%)

Test statistic \( F \) is given by

\[
F = \frac{S_1^2}{S_2^2} \quad \text{(if } S_1^2 > S_2^2 \text{)} \quad \text{or} \quad F = \frac{S_2^2}{S_1^2} \quad \text{(if } S_2^2 > S_1^2 \text{)}
\]

\( S_1^2 \) = sample variance of period-I (1993-94 to 2002-03)

\( S_2^2 \) = sample variance of period-II (2003-04 to 2014-15)
The signific

Here the test statistic is given by

\[ t = \frac{\Delta CV}{SE(\Delta CV)} \]

The test statistic follows t-distribution with \((2n-2)\) degrees of freedom, where \(n\) is the number of observations in each period and \(SE(\Delta CV)\) is the standard error of the change in coefficient of variation, which is given by,

\[ SE(\Delta CV) = \frac{CV^*}{(n_1 + n_2)^{\frac{1}{2}}} \]

Where \(CV^*\) is the CV for the combined periods which is given by,

\[ CV^* = \frac{(n_1 - 1) \times CV_{1} + (n_2 - 1) \times CV_{2}}{n_1 + n_2 - 2} \quad [11] \]

\(n_1\) and \(n_2\) are number of observations in Period-I and Period-II respectively.

To decide on the direction of the changes (positive or negative) in CV, we perform one-tailed (right or left tailed) tests.

3. RESULTS AND DISCUSSION

Figs. 1, 2 and 3 show the scatter plot of area, yield and production of rabi food grains in Odisha for the year 1993-94 to 2014-15. It is observed from the Fig. 1 that the area under rabi food grains in Odisha shows an uneven decrease in the first 10 years and then shows constant increase in area up to the last 12 years with slight increase in the last two years i.e. 2013-14 to 2014-15.

It is seen from the Fig. 2 that the yield of rabi food grains shows a slight decrease in the first 10 years of study period (1993-94 to 2002-03) with a sudden and irregular increase in the middle of first period i.e. in the year 1999-2000. Then after a steady increase in the yield of rabi food grains is marked in the period from 2003-04 to 2014-15.

It is seen from the Fig. 3 that the production of rabi food grains shows an uneven increase and decrease in the first 10 years of study period. After 10 years of study period it shows a constant increase in production of rabi food grains up to the year 2009-10 then shows slight increase and
decrease in production up to the last years of study period.

On basis of scatter plot of the data on area, yield and production of rabi food grains in Odisha the entire period of study is divided into two periods i.e. period-I (1993-94 to 2002-03) and period-II (2003-04 to 2014-15) on basis of scatter plot.

Table 1 reveals that there is significant increase in mean yield and mean production of rabi food grains in Odisha whereas there is no significant change in mean area from Period-I to Period-II. Mean area in Bhadrak, Cuttack and Kendrapada districts show significant change whereas other coastal districts do not show any significant change. Mean yield show significant increase in Balasore, Ganjam and Puri districts whereas it shows significant decrease in Cuttack, Jagatsingpur and Kendrapada districts. Mean production show significant decrease in Balasore and Jagatsingpur districts whereas it shows significant increase from Period-I to Period-II in Puri districts and in other coastal districts mean production don't show any significant change.

Table 2 shows that, there is significant decrease in variance of area of rabi food grains of Odisha from Period-I to Period-II but variance of yield and production do not show any significant change. Variance of area shows significant decrease in Balasore, Bhadrak, Cuttack and Puri districts, whereas, in the remaining districts, it shows no significant change from Period-I to Period-II. Yield variance show significant decrease in Cuttack, Jagatsingpur, Kendrapada and Khurda districts from Period-I to Period-II and non-significant in other coastal districts of Odisha. In Cuttack, Jagatsingpur and Kendrapada districts, variance of production of rabi food grains show significant decrease from Period-I to Period-II.
Table 1. Change in mean area, yield and production of rabi food grains from period-I (1993-94 to 2002-03) to period-II (2003-04 to 2014-15) in coastal districts of Odisha and the state as a whole

<table>
<thead>
<tr>
<th>Districts</th>
<th>Area (in '000 ha)</th>
<th>Yield (in Kg/ha)</th>
<th>Production (in '000 MT)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M_1$</td>
<td>$M_2$</td>
<td>$\Delta M$</td>
</tr>
<tr>
<td>Balasore</td>
<td>53.39</td>
<td>49.44</td>
<td>-3.96(4.593)</td>
</tr>
<tr>
<td>Bhadrak</td>
<td>37.76</td>
<td>26.92</td>
<td>-10.84 (4.318)</td>
</tr>
<tr>
<td>Cuttack</td>
<td>97.5</td>
<td>110.68</td>
<td>13.18 (5.934)</td>
</tr>
<tr>
<td>Ganjam</td>
<td>169.27</td>
<td>190.63</td>
<td>21.36 (14.382)</td>
</tr>
<tr>
<td>Jagatsinghpur</td>
<td>48.4</td>
<td>53.57</td>
<td>5.17 (2.298)</td>
</tr>
<tr>
<td>Kendrapada</td>
<td>60.9</td>
<td>78.88</td>
<td>17.98 (4.943)</td>
</tr>
<tr>
<td>Khurda</td>
<td>55.29</td>
<td>52.9</td>
<td>-2.39 (4.696)</td>
</tr>
<tr>
<td>Puri</td>
<td>98.43</td>
<td>105.39</td>
<td>6.96 (9.541)</td>
</tr>
<tr>
<td>Odisha</td>
<td>1440.3</td>
<td>1584.6</td>
<td>144.25 (85.960)</td>
</tr>
</tbody>
</table>

(Values in the parentheses indicates standard error)

$M_1$: Mean area/production/yield of period-I; $M_2$: Mean area/production/yield of period-II; $\Delta M = M_2 - M_1$

*Significant at 5% level of significance; **Significant at 1% level of significance

Table 2. Change in variance of area, yield and production of rabi food grains from period-I (1993-94 to 2002-03) to period-II (2003-04 to 2014-15) in coastal districts of Odisha and the state as a whole

<table>
<thead>
<tr>
<th>Districts</th>
<th>Area (in '000 ha)</th>
<th>Yield (in Kg/ha)</th>
<th>Production (in '000 MT)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$V_1$</td>
<td>$V_2$</td>
<td>$\Delta V$</td>
</tr>
<tr>
<td>Balasore</td>
<td>219.58</td>
<td>25.94</td>
<td>-190.04</td>
</tr>
<tr>
<td>Bhadrak</td>
<td>164.50</td>
<td>46.75</td>
<td>-117.76</td>
</tr>
<tr>
<td>Cuttack</td>
<td>354.01</td>
<td>34.79</td>
<td>-319.21</td>
</tr>
<tr>
<td>Ganjam</td>
<td>1476.65</td>
<td>560.66</td>
<td>-915.99</td>
</tr>
<tr>
<td>Jagatsinghpur</td>
<td>42.95</td>
<td>8.71</td>
<td>-34.24</td>
</tr>
<tr>
<td>Kendrapada</td>
<td>184.39</td>
<td>6.26</td>
<td>-178.13</td>
</tr>
<tr>
<td>Khurda</td>
<td>182.82</td>
<td>74.22</td>
<td>-108.59</td>
</tr>
<tr>
<td>Puri</td>
<td>888.09</td>
<td>163.73</td>
<td>-724.36</td>
</tr>
<tr>
<td>Odisha</td>
<td>70075.04</td>
<td>15946.93</td>
<td>-54128.1</td>
</tr>
</tbody>
</table>

$V_1$: Area/production/yield variance of period-I; $V_2$: Area/production/yield variance of period-II; $\Delta V = V_2 - V_1$

*Significant at 5% level of significance; **Significant at 1% level of significance
Table 3. Change in coefficient of variation (C.V. %) of area, yield and production of rabi food grains from period-I (1993-94 to 2002-03) to period-II (2003-04 to 2014-15) in coastal districts of Odisha and the state as a whole

<table>
<thead>
<tr>
<th>Districts</th>
<th>Area CV (%)</th>
<th>Yield CV (%)</th>
<th>Production CV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CV₁</td>
<td>CV₂</td>
<td>ΔCV</td>
</tr>
<tr>
<td>Odisha</td>
<td>18.379</td>
<td>7.969</td>
<td>-10.409(2.698)</td>
</tr>
</tbody>
</table>

(Values in the parentheses indicates standard error)

CV₁: Area/production/yield coefficient of variation of period-I
CV₂: Area/production/yield coefficient of variation of period-II; ΔCV=CV₂- CV₁
*Significant at 5% level of significance; **- Significant at 1% level of significance
Table 3 shows that change in coefficient of variation of area of rabi food grains of Odisha show significant decrease from Period-I to Period-II and change in C.V. of yield and production show no significant change from Period-I to Period-II. In Bhadrad and Jagatsingpur districts change in coefficient of variation of area of rabi food grains do not show significant change from Period-I to Period-II, whereas, other coastal districts show significant decrease in area of rabi food grains from Period-I to Period-II. In Cuttack, Jagatsingpur, Kendrapada, Khurdha and Puri districts, change in coefficient of variation of yield of rabi food grains show significant decrease from Period-I to Period-II. In Cuttack, Jagatsingpur, Kendrapada, Khurdha and Puri districts, change in coefficient of variation of production of rabi food grains show significant decrease and in remaining districts, it shows no significant change from Period-I to Period-II.

4. SUMMARY AND CONCLUSIONS

The study of scatter diagrams of area, yield and production of rabi food grains of Odisha reveals that certain change is observed after 10th year of study period i.e. after 2002-03. So the whole period of study is divided into two periods on the basis of change in scatter plot data. Change in mean yield and mean production of rabi food grains of Odisha show significant increase from period-I to period-II. Mean production show significant decrease in Balasore and Jagatsingpur districts and in Puri districts, mean production of rabi food grains show significant increase from Period-I to Period-II. Significant decrease in variance of area of rabi food grains of Odisha is marked from Period-I (1993-94 to 2002-03) to Period-II (2003-04 to 2014-15) but variance of yield and production do not show any significant change. In Cuttack, Jagatsingpur and Kendrapada districts, variance of production of rabi food grains show significant decrease from Period-I to Period-II. Change in coefficient of variation of area of rabi food grains of Odisha show significant decrease from Period-I to Period-II. Change in coefficient of variation of area of rabi food grains of Odisha show significant decrease from Period-I to Period-II(1993-94 to 2002-03) to Period-II(2003-04 to 2014-15). In the districts like Bhadrad, Ganjam and Kendrapada, change in coefficient of variation of area show significant decrease from Period-I to Period-II. Contribution of yield and area effect towards change in mean production of rabi food grains is 59.93% and 32.95% respectively. From the overall study, it is observed that, in case of rabi food grains of Odisha, significant increase in mean production from Period-I to Period-II is due increase in mean yield from Period-I to Period-II. The variability in production of rabi food grains has increased for Odisha and for all the coastal districts except Balasore in Period-II as compared to period-I. This increase in variability might be due to uneven irrigation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES


