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Instability in area, production and productivity of major cereal and oilseed crops in the state of Rajasthan

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Abstract
This study was conducted in the state of Rajasthan. Two major crop groups viz; cereals (pearlmillet, maize and wheat) and oilseeds (soyabean and rapeseed and mustard) were selected for analysis. The crops in the above groups having five per cent or more area under cultivation in a district were selected. The districts were selected on the basis of last five years average (2005-06 to 2009-10). The secondary data were collected from published records and reports of the Directorate of Economics and Statistics, Government of Rajasthan, Jaipur and official website of Rajasthan Agriculture Department www.krishi.rajasthan.gov.in. The study period encompassed a duration of 58 years starting from; 1956-57 to 2014-15.
The variation (as measured in terms of coefficient of variation adjusted for trend) in area, production and yield of cereal and oilseed crops varied from over the periods and districts in the state of Rajasthan during- 1956-57 to 2014-15.

Keywords: Cereals, oilseeds, wheat, soyabean, districts, variation etc.

1. Introduction
Agricultural development of India has been agitating the minds of Indian politicians, the policy makers, the planners, the agricultural scientists and farmers since independence. A number of agricultural development plans gave rise to institutional and technological changes in the foodgrains production in the country. There are many empirical studies witnessing that the area under some crops increased over time while under some others it either decreased and /or remained stagnant. Despite a technological breakthrough in agriculture, the Indian agriculture is still a gamble of monsoon. This leads to high degree of risks and uncertainty in production, prices and farm incomes because the farmers are often not sure about the outcomes from agriculture due to weather and market induced risks. In spite of the impressive achievements, the Indian agricultural sector continues to face poor infrastructure conditions. As a result, the productivity levels of many major crops in India are not comparable with the yields obtained in agriculturally advanced countries. The country's agriculture has gained in strength and resilience since independence, although growth in agriculture is highly skewed over regions and crops.
The instability in area, production and productivity leads to excessive demand and supply gape in the economy. The fluctuations in production (year to year) induce price instability and inefficiency in production, employment and income distribution (Lipton, 1970). It is, therefore, necessary to take the appropriate policy measures to stabilize the production. A pre-requisite of policy action is the measurement of instability, identification of its sources and means of control. In order to devise strategies for minimizing these fluctuations in agriculture a clear cut idea about the extent or degree of fluctuation in area, production and productivity of different crops in a particular area is required. The knowledge of sources of instability in the production provides some guideline to agricultural scientists interested in finding the ways of reducing it. Because statistical identities provide no formal insight into the causes of the various component terms, comparative studies can help.
Agriculture has also been an important sector in the state of Rajasthan due to large dependencies of the population.

It contributes 24.76 per cent (2017-18) in State GSDP at constant prices 2011-12 (Economic Review 2017-18 published in february-2018). Though the share of agriculture sector has been declining or stagnant over time, it still remains a predominant sector in respect of labour absorption. The sector, therefore, deserved to be assigned due importance for its sustainable and balanced development at the state level too. Therefore, different development programmes were initiated in every Five Year Plan covering different aspects of agricultural development. Land is one of important factor of production and is fixed. The districts/ state level study will be useful to formulate micro-level agricultural policies.

2. Methodology

This study was conducted in the state of Rajasthan. Two major crop groups viz; cereals (pearlmillet, maize and wheat) and oilseeds (soyabean and rapeseed and mustard) were selected for analysis. The crops in the above groups having five per cent or more area under cultivation in a district were selected. The districts were selected on the basis of last five years average (2005-06 to 2009-10). The secondary data were collected from published records and reports of the Directorate of Economics and Statistics, Government of Rajasthan, Jaipur and official website of Rajasthan Agriculture Department www.krishi.rajasthan.gov.in. The study period encompassed a duration of 58 years starting from; 1956-57 to 2014-15. For the purpose of drawing meaning full conclusions, the study period was sub divided as under: Period-I (1956-57 to 1965-66), Period-II (1966-67 to 1988- 89), Period-III (1989-90 to 2003-04), Period-IV (2004-05 to 2014-15) and overall Period (1956-57 to 2014-15).

The general method that is used for the measurement of instability in the data is the coefficient of variation (CV) which is given by

$$CV = \frac{Sd}{m} \times 100$$

Where,

Sd = Standard deviation of the variate values in respect of which instability is measured, and

M = Mean of the variate values

However, C.V. is an appropriate method for measuring instability in case of data not showing any kind of trend. When the data show some kind of trend-linear or non-linear, this method fails to take into account any time trend in the variate values or data. So instead of using C.V. as a measure of instability, Mitra (1989) suggested another measure of instability for general application, in the time series data. This method is known as Instability-Index method wherein the Instability - Index (I) is obtained as follows:

After determining the trend (linear or non-linear) in the time series data the residual sum of squares (RSS) are obtained from the detrended series (Y - $\hat{Y}$). These RSS give the extent of overall fluctuations around the trend. In order to make it unit free it is divided by the square of the mean to have an index of instability (I) for the values (Y) as :

$$\frac{RSS}{\bar{Y}^2} = \frac{\Sigma(Y-\hat{Y})^2}{\bar{Y}^2} \qquad (1)$$

$$\frac{RSS}{\bar{Y}^2} = (1-R^2) \quad \frac{\Sigma(Y-\bar{Y})^2}{\bar{Y}^2} \qquad (2)$$

Where,

$\hat{Y}$ = the estimated trend, and

R^2 = the coefficient of determination for the estimated trend.

On multiplying LHS and RHS of equation (2) by

$\frac{(100)^2}{n-1}$; The equation takes the following form,

$$\frac{(100)^2}{n-1} \quad \frac{RSS}{\bar{Y}^2} = \frac{(100)^2 \Sigma (Y-\bar{Y})^2 (1-R^2)}{(n-1) \quad \bar{Y}^2}$$

$= (CV)^2 . (1-R^2)$

If the LHS of equation (3) is denoted as I; *i.e.* Index of instability, then

$I = (CV)^2 (1-R^2)$

Obviously $I \leq CV^2$

This index of instability (I) as suggested by Mitra is a general measure of mapping instability in the data showing any kind of trend.

Since the index of instability gives rise to larger values which unlike C.V. make the interpretation not so easy to understand, the square root of index of instability (I) was worked out which was nothing but the coefficient of variation adjusted for trend (CVT).

3. Results and Discussion

Instability in Area, Production and Productivity of major cereal and oilseed Crops

An attempt has been made to measure the magnitude of instability in area, production and productivity of major cereal and oilseed crops in Rajasthan state for the period-I (1956-57 to 1965-66), period-II (1966-67 to 1988-89), period-III (1989-90 to 2003-04), period-IV (2004-05 to 2014-15) and the overall period (1956-57 to 2014-15). The results of instability are presented in Table-1 to 5. The coefficients of variation were computed for measuring the degree of instability in the parameters after removing the trend from the data. The coefficient of variation is a statistical measure to access the extent of variation in a set of data.

Instability is a major problem of every sector of the economy. Agriculture sector is prone to risk and uncertainties, which makes it necessary to measure the growth coupled with instability so as to access the real important agricultural parameters in the past. It is important to have quantitative measure of instability, so that the seriousness of the problem can be accessed objectively.

Table-1 depicts the instability in area, production and productivity of pearlmillet crop in selected districts of Rajasthan. The table shows that the estimates of coefficients of variation adjusted for trend (CVT) for area under pearlmillet crop ranged from 4.77 per cent in Barmer district to 12.05 per cent in Jhunjhunu district during period-I; the magnitude of variation in yield ranged from 20.00 per cent in Sikar district to 74.01 per cent in Barmer district and in production from 19.96 per cent in Sikar to 74.21 per cent in Barmer district during the same period.

During period-II the variation in area ranged from 9.81 per cent in Barmer to 21.88 per cent in Jalore district; in yield from 28.62 per cent in Jaipur to 97.51 per cent in Jalore district and in production the variation was in line with that of yield.

Table 1: Instability in area, production and productivity of pearlmillet in selected districts of Rajasthan as well as in the state as a whole (1956-57 to 2014-15)

Districts	Coefficient of variation adjusted for trend (CVT)														
	Period-I			Period-II			Period-III			Period-IV			Overall Period		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Barmer	4.77	74.21	74.01	9.81	95.19	89.21	10.83	96.09	89.69	9.85	74.88	71.31	14.99	87.21	86.64
Jodhpur	6.78	51.88	53.12	13.68	96.04	90.92	25.76	102.46	83.17	10.87	66.29	61.18	17.69	102.41	94.32
Nagaur	7.71	29.15	29.05	11.02	65.96	59.97	15.20	54.96	45.20	9.48	48.50	42.20	13.36	61.13	55.11
Churu	6.59	34.83	36.37	12.03	76.06	69.54	10.97	80.92	76.50	9.31	55.27	50.56	12.98	79.63	75.10
Jalore	6.31	35.76	32.53	21.88	106.24	97.51	16.82	104.55	90.83	4.98	56.09	56.90	16.83	96.09	91.64
Sikar	5.85	19.96	20.00	14.14	63.68	53.52	9.69	45.28	35.84	4.85	29.18	27.51	11.33	56.82	49.24
Jaipur	8.61	21.33	24.37	18.83	42.89	28.62	14.09	48.32	39.73	4.79	20.12	20.77	16.12	43.83	36.54
Jhunjhunu	12.05	36.53	34.19	12.91	75.73	69.94	10.82	70.30	61.91	6.33	39.71	34.41	11.84	69.27	64.70
Rajasthan	4.17	17.67	18.22	12.84	55.59	48.76	12.78	63.12	47.78	8.94	29.37	25.71	11.97	54.26	48.49

Period-I (1956-57 to 1965-66), Period-II (1966-67 to 1988-89), Period-III (1989-90 to 2003-04), Period-IV (2004-05 to 2014-15) and the Overall Period (1956-57 to 2014-15)

During period-III it ranged from 9.69 per cent in Sikar to 25.76 per cent in Jodhpur for area; from 35.84 per cent in Sikar to 90.83 per cent in Jalore for yield. The magnitude of production was almost same as that of yield.

During period-IV the instability in area of pearlmillet crop ranged from 4.79 per cent in Jaipur to 10.87 per cent in Jodhpur district; that of yield varied from 20.77 per cent in Jaipur to 71.31per cent in Barmer district and of production from 20.12 per cent in Jaipur to 74.88 per cent in Barmer district.

During overall period the variation in area of the crop varied from 11.33 per cent in Sikar to 17.69 per cent in Jodhpur district; in yield from 36.54 per cent in Jaipur to 94.32 per cent in Jodhpur district and in production from 43.83 per cent in Jaipur to 102.41 per cent in Jodhpur district.

In the state the instability in area, production and yield of pearlmillet crop was of the order of 4.17,17.67,18.22 per cent during period-I, 12.84,55.59,48.76 per cent in period-II, 12.78,63.12,47.78 per cent in period-III, 8.94,29.37,25.71per cent in period-IV and 11.97,54.26,48.49 per cent during overall period.

The results of instability in area, production and yield of maize in Rajasthan state are presented in table- 2. The table depicts that the estimates of coefficients of variation adjusted for trend (CVT) for area ranged from 3.42 per cent in Chittorgarh to 9.94 per cent in Dungarpur district; for yield it ranged from 13.62 per cent in Bhilwara to 24.87 per cent in Dungarpur district and for production from 16.84 per cent in Bhilwara to 27.53 per cent in Dungarpur district during period-I.

During period-II area ranged from 5.16 per cent in Chittorgarh to 11.53 per cent in Dungarpur district; yield varied from 31.83 per cent in Chittorgarh to 62.64 per cent in Banswara district and production varied from 33.00 per cent in Chittorgarh to 65.92 per cent in Banswara district.

Table 2: Instability in area, production and productivity of maize in selected districts of Rajasthan as well as in the state as a whole (1956-57 to 2014-15)

Districts	Coefficient of variation adjusted for trend (CVT)														
	Period-I			Period-II			Period-III			Period-IV			Overall Period		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Udaipur	3.96	16.90	16.95	5.50	37.72	36.56	11.71	30.75	26.55	3.04	22.22	20.79	12.62	31.91	31.57
Bhilwara	5.47	16.84	13.62	7.26	40.88	38.93	4.58	42.01	37.02	6.94	28.21	26.76	8.24	42.43	37.96
Chittore	3.42	24.09	23.64	5.16	33.00	31.83	3.73	26.03	22.78	12.38	22.18	14.38	11.03	27.57	5.25
Banswara	4.23	19.99	17.76	6.88	65.92	62.64	4.26	36.52	33.76	5.18	38.44	38.56	6.39	54.12	47.24
Dungarpur	9.94	27.53	24.87	11.53	54.02	52.62	9.39	38.29	35.52	9.23	48.75	48.83	15.00	52.17	44.43
Rajsamand	NA	NA	NA	NA	NA	NA	2.29	46.48	44.60	3.91	19.32	20.14	3.52	35.80	36.02
Rajasthan	4.02	14.99	13.76	6.64	35.50	34.90	4.34	30.07	25.02	6.14	20.40	17.76	7.60	30.54	29.46

NA: Data not available

Period-I (1956-57 to 1965-66), Period-II (1966-67 to 1988-89), Period-III (1989-90 to 2003-04), Period-IV (2004-05 to 2014-15) and the Overall Period (1956-57 to 2014-15)

During period –III the instability in area of maize ranged from 2.29 per cent in Rajsamand to 11.71 per cent in Udaipur district; yield varied from 22.78 per cent in Chittorgarh to 44.60 per cent in Rajsamand and production varied from 26.03 per cent in Chittorgarh to 46.48 per cent in the district of Rajsamand.

During period-IV variation in area of the crop ranged from 3.04 per cent in Udaipur to 12.38 per cent in Chittorgarh district; yield varied from 14.38 per cent in Chittorgarh to 48.83 per cent in Dungarpur district and the magnitude of production ranged from 19.32 per cent in Rajsamand to 48.75 per cent in Dungarpur district.

During overall period coefficient of variation for area of maize varied from 3.52 per cent in Rajsamand to 15.00 per cent in Dungarpur district; yield ranged from 25.25 per cent in Chittorgarh to 47.24 per cent in Banswara district and production varied from 27.57 per cent in Chittorgarh to 54.12 per cent in Banswara district.

In the state of Rajasthan variation in area, production and yield of maize recorded 4.02,14.99,13.76 per cent during

period-I, 6.64,35.50,34.90 per cent in period-II, 4.34,30.07,25.02 per cent in period-III, 6.14,20.40,17.76 per cent in period-IV and 7.60,30.54,29.46 per cent during overall period.

Table-3 depicts the instability (measured in terms of CVT) in area, production and yield of wheat crop in selected districts of Rajasthan and the state as a whole across the periods.

It is evident from the table that area under the crop registered least variation across the periods. However, the magnitude differed across the periods and districts. The variability in yield was more than that in area but less than production across the periods and districts. The magnitude of instability in area varied from 4.59 per cent in period-IV in the district of Alwar to as high as 22.20 per cent in period-III in the district of Sriganganagar; for yield from 7.90 per cent in period-IV in district of Alwar to as high as 25.55 per cent in period-I in district of Sriganganagar and for production from 7.45 per cent in period-IV in district of Hanumangarh to as high as 30.71 per cent in period-I in district of Sriganganagar.

Table 3: Instability in area, production and productivity of wheat in selected districts of Rajasthan as well as in the state as a whole (1956-57 to 2014-15)

Districts	Coefficient of variation adjusted for trend (CVT)														
	Period-I			Period-II			Period-III			Period-IV			Overall Period		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Hanumangarh*	NA	NA	NA	NA	NA	NA	9.48	17.65	11.34	4.95	7.45	8.15	10.55	15.57	9.49
Sriganganagar	13.04	30.71	25.55	15.37	22.44	15.08	22.20	26.00	11.19	5.97	14.40	10.96	30.68	33.96	18.15
Alwar	8.55	26.87	20.27	13.93	22.40	12.61	6.77	13.79	11.07	4.59	8.27	7.90	14.90	20.78	15.65
Bharatpur	9.67	19.61	14.12	16.50	23.95	17.93	10.75	15.32	10.92	9.21	11.88	9.84	16.03	20.94	14.35
Jaipur	10.79	18.75	12.07	12.59	19.46	14.11	18.27	24.57	14.13	5.66	15.30	11.40	27.47	28.09	14.74
Rajasthan	9.09	15.80	8.61	12.88	14.09	8.88	14.20	16.45	9.10	6.70	9.75	6.91	13.33	16.89	10.03

* Instability relates to the period 1990-91 to 2014-15

NA: Data not available

Period-I (1956-57 to 1965-66), Period-II (1966-67 to 1988-89), Period-III (1989-90 to 2003-04), Period-IV (2004-05 to 2014-15) and the Overall Period (1956-57 to 2014-15)

In the state the instability in area for the crop varied from 6.70 per cent in period-IV to as high as 14.20 per cent in period-III and for yield from 6.91per cent in period-IV to as high as 9.10 per cent in period-III. The magnitude of production was almost same as that of yield.

The estimates of coefficient of variation adjusted for trend (CVT) for area under soyabean crop ranged from 13.89 per cent in Kota to 25.64 per cent in Bundi district during period-II (table-4); that of yield from13.12 per cent in Kota to 100.66 per cent in Chittorgarh district and for production from 9.53 per cent in Kota to 133.46 per cent in Chittorgarh district during the same period.

During period-III it ranged from 19.82 per cent in Chittorgarh district to 36.76 per cent in Kota district for area; from 25.93 per cent in Kota to 31.83 per cent in Bundi district for yield and from 35.01 per cent in Chittorgarh to 52.47 per cent in Baran district for production.

During period-IV the variation in area of the crop varied from 4.91 per cent in Jhalawar to 47.98 per cent in Chittorgarh district; in yield from 12.26 per cent in Chittorgarh to 25.87 per cent in Baran district and for production from 23.91 per cent in Jhalawar to 42.57 per cent in Chittorgarh district.

During overall period the instability in area of soyabean crop ranged from 26.16 per cent in Bundi to 47.40 per cent in Chittorgarh district; in yield from 23.27 per cent in Kota to 33.31per cent in Chittorgarh district. The magnitude of production was almost same as that of area.

In the state the coefficient of variation for area, production and yield of the crop was of the order of 9.90, 19.93, 15.59 per cent during period-II, 21.55, 36.90, 24.71 per cent during period-III, 10.13, 18.89, 17.65 per cent during period-IV and 29.79, 35.46, 22.68 per cent during overall period.

It is evident from table-5 that the instability in area of rapeseed and mustard crop ranged from 14.72 per cent in Bharatpur to 60.49 per cent in Sriganganagar district during period-I; the magnitude of variation in yield ranged from 25.51 per cent in Bharatpur to 38.56 per cent in Sriganganagar district and in production from 31.83 per cent in Bharatpur to 90.38 per cent in Tonk district during the same period.

Table 4: Instability in area, production and productivity of soyabean in selected districts of Rajasthan as well as in the state as a whole (1983-84 to 2014-15)

Districts	Coefficient of variation adjusted for trend (CVT)											
	Period-II			Period-III			Period-IV			Overall Period		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Jhalawar	18.27	116.65	97.99	24.18	39.48	31.23	4.91	23.91	16.68	35.32	44.03	32.94
Baran*	NA	NA	NA	32.56	52.47	26.37	27.79	40.60	25.87	30.15	48.75	30.82
Kota	13.89	9.53	13.12	36.76	49.24	25.93	21.01	26.77	18.24	36.15	41.98	23.27
Chittorgarh	17.95	133.46	100.66	19.82	35.01	28.69	47.98	42.57	12.26	47.40	49.99	33.31
Bundi	25.64	69.32	51.36	29.96	44.00	31.83	16.69	28.75	20.54	26.16	40.88	31.19
Rajasthan	9.90	19.93	15.59	21.55	36.90	24.71	10.13	18.89	17.65	29.79	35.46	22.68

* Instability relates to the period 1990-91 to 2014-15

NA: Data not available

Period-II (1983-84 to 1988-89), Period-III (1989-90 to 2003-04), Period-IV (2004-05 to 2014-15) and the Overall Period (1983-84 to 2014-15)

Table 5: Instability in area, production and productivity of rapeseed & mustard in selected districts of Rajasthan as well as in the state as a whole (1956-57 to 2014-15)

Districts	Coefficient of variation adjusted for trend (CVT)														
	Period-I			Period-II			Period-III			Period-IV			Overall Period		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Alwar	15.63	43.81	32.40	38.09	63.98	42.57	9.13	23.45	21.17	5.47	13.66	12.44	32.39	42.26	31.61
Sriganganagar	60.49	49.43	38.56	31.67	37.97	18.83	21.26	30.62	17.88	10.32	29.44	25.14	37.74	41.77	28.85
Bharatpur	14.72	31.83	25.51	38.52	58.22	32.03	20.25	21.20	11.75	7.08	13.58	12.13	36.94	38.62	24.99
Tonk	47.81	90.38	36.13	104.35	105.79	21.77	38.09	50.00	20.09	21.06	31.95	22.73	49.44	57.93	29.80
Sawai Madhopur	34.33	46.67	32.45	61.56	84.27	35.21	34.38	36.86	21.17	12.53	18.90	13.02	49.22	59.09	29.56
Rajasthan	20.11	33.59	25.46	30.51	39.97	25.55	22.45	24.36	12.24	11.79	16.59	11.15	32.33	33.40	21.38

Period-I (1956-57 to 1965-66), Period-II (1966-67 to 1988-89), Period-III (1989-90 to 2003-04), Period-IV (2004-05 to 2014-15) and the Overall Period (1956-57 to 2014-15)

During period-II the variation in area of crop ranged from 31.67 per cent in Sriganganagar to 104.35 per cent in Tonk district and for yield from 18.83 per cent in Sriganganagar to 42.57 per cent in Alwar district. The magnitude of production was almost same as that of area.

During period-III the coefficient of variation for area varied from 9.13 per cent in Alwar to 38.09 per cent in Tonk district; for yield 11.75 per cent in Bharatpur to 21.17 per cent in Alwar and Sawai-madhopur district and for production 21.20 per cent in Bharatpur to 50.00 per cent in Tonk district.

During period-IV it ranged from 5.47 per cent in Alwar to 21.06 per cent in Tonk district for area; from 12.13 per cent in Bharatpur to 25.14 per cent in Sriganganagar district for yield and from 13.58 per cent in Bharatpur to 31.95 per cent in Tonk district for production of the crop.

During overall period the variation in area of the crop varied from 32.39 per cent in Alwar to 49.44 per cent in Tonk district; for yield from 24.99 per cent in Bharatpur to 31.61 per cent in Alwar district and for production from 38.62 per cent in Bharatpur to 59.09 per cent in Sawai-madhopur district.

In the state the instability in area, production and yield of rapeseed and mustard crop was of the order of 20.11, 33.59, 25.46 per cent during period-I, 30.51, 39.97, 25.55 per cent in period-II, 22.45, 24.36, 12.24 per cent in period-III, 11.79, 16.59, 11.15 per cent in period-IV and 32.33, 33.40, 21.38 per cent during overall period.

4. Conclusions

The study results revealed that the instability (as measured in terms of coefficient of variation adjusted for trend) in area of pearlmillet in area, production and yield was of the order of 11.97, 54.26 and 48.49 per cent, maize recorded 7.60, 30.54 and 29.46 per cent and wheat registered 13.33, 16.89 and 10.03 per cent in the Rajasthan state during- 1956-57 to 2014-15. The coefficient of variation for area, production and yield of the soyabean crop was of the order of 29.79, 35.46 and 22.68 per cent, respectively during- 1983-84 to 2014-15 and for rapeseed and mustard 32.33, 33.40 and 21.38 per cent during- 1956-57 to 2014-15 in the state of Rajasthan.

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