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GROWTH AND INSTABILITY IN CROP OUTPUT IN UTTAR PRADESH—A LONG TERM PERSPECTIVE

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ABSTRACT

Pattern of growth and instability in crop output in Uttar Pradesh from 1891-92 to 1985-86 split in three sub-periods –I : 1891-92 to 1946-47, II : 1949-50 to 1965-66 and III : 1966-67 to 1985-86 has been studied. Area played a major role relative to yield in increasing or decreasing output of various crops in Period II over Period I, with the exception of bajra, wherein yield contributed to increased production inspite of fall in the acreage. In Period III over Period II the contribution of yield was more relative to area in increasing the output of rice, maize, jowar, bajra and sugarcane; area and yield both contributed almost equally in case of wheat. It also came out that the instability in the output of the two important crops of the state, viz., wheat and sugarcane declined consistent y over the three successive periods. Though the production of rice increased considerably during the two periods after independence, the increase being higher in the third period, side by side the instability also increased due to wide fluctuations in yield.

Introduction

As a result of concerted efforts made in the country after independence, there has been a phenomenal increase in the agricultural production. A major portion of this increased production is attributed to the new 'seed fertilizer' based technology introduced during the mid sixties. However, as a high percentage of cultivable area (about 65) in the country still depends on rainfall, the agricultural output fluctuates considerably from year to year. While some studies (see, e.g., Barker *et. al*, 1981; Mehra, 1981; Hazell, 1982; Ray, 1983) indicate that the new farm technology has added to instability in production, others (Dhawan, 1987; Deshpande, 1986 and Dev, 1987) show a decline. For example, Mehra (1981), on the basis of a comparative analysis of instability in production between the periods before and after the introduction of new farm technology—1950 to 1965 and 1968 to 1978, concluded that production instability has increased in the latter period and fluctuations in yield turned out to be the dominant force behind this instability. Hazell (1982) examined the sources of change in the variance of all India total cereal production between the two periods—1955 to 1965 and 1968 to 1978 and found that in the second period the synchronised movements in area, yield and cropping pattern were responsible for increased instability in the cereal production. On the

other hand, Deshpande (1986) showed that instability decreased alongwith increase in growth rates in Maharashtra. Dev (1987) carried out an inter-state analysis which revealed that instability declined in most states, for wheat crop, along with high growth rates. He also concluded that there is no basis to believe the hypothesis that high growth causes high instability. Also, Dhawan (1987) showed that irrigation causes a substantial reduction in instability in area, yield and output.

Measurement of instability and identification of sources of instability continues to be an important area of research. The present study pertains to the state of Uttar Pradesh, which occupies an important place in the country's agricultural production. The study was undertaken to examine the pattern of growth and instability in the output of various crops over a long period of time.

Data and Methodology

This study is based on time-series data on area, production and yield of all the major crops of Uttar Pradesh. To have a long term historical perspective of agricultural performance of the state, the time periods taken are as under :

Period I	:	1891-92 to 1946-47
Period II	:	1949-50 to 1965-66
Period III	:	1966-67 to 1985-86

The data for Period I are taken from Blyn's work (1966), while for Period II and III, 'Estimates of Area, Production and Yield' published by Directorate of Economics and Statistics is the main source.

For measuring per annum increase in area (A), production (P) and yield (output per hectare, Y) of various crops, linear and exponential functions of time were fitted to the values of these variables during the various periods. By and large, it was observed that linear functions were better fit in terms of significance of regression coefficients and variation explained. As such, these functions were selected for further analysis.

Inter-period variation in the output of a particular crop can be attributed to inter-period change in the area under the crop and/or inter-period change in the productivity. In order to find the relative contribution of each of these factors in output change, the following mathematical identity was used :

$$P_1 - P_0 = A_1Y_1 - A_0Y_0$$

$$= A_0\triangle Y + Y_0\triangle A + \triangle A\triangle Y \qquad \ldots(1)$$

Where $\triangle Y = Y_1 - Y_0$

and $\triangle A = A_1 - A_0$

The suffixes 0 and 1 denote the respective levels of these variables in the base and in the terminal year. To smoothen out the effect of random fluctuations, averages of three years' figures before the start of the period were taken as the base level values and the averages of last three years' of a period as the terminal values. It may be noted that the first term on the right hand side of (1) represents the contribution of yield in the increased production at the base level of area and the second term is the contribution of area at the base level of yield. The third term indicates the share of interaction of both area and yield.

To measure the magnitude of fluctuations within various periods, a coefficient, "Measure of Relative Fluctuations (MRF)", defined below, has been used :

$$MRF = \text{Variance/mean}^2 \qquad ...(2)$$

Besides permitting inter-temporal comparisons for the same crop, this measure, being free from units of data measurement, also allows for inter-crop comparisons of variability.

The variance in (2), in presence of a time trend was estimated by error mean square around the trend line, but when data exhibited no trend, the sample variance was used to estimate it. Another important advantage of using (2) is that the variability in production could be split up into variability in its constituents, viz., variabilily in area and in yield as follows :

$$MRF(P)=MRF(A)+MRF(Y)+MRF(A)\ MRF(Y) \qquad ...(3)$$

A proof of (3), though simple, is given in 'Appendix' for the sake of completeness.

Results and Discussion

Growth in Crop Output

While interpreting the results of the first period, it is essential to keep in mind the agricultural situation that prevailed in the country at that time. Indian agriculture during this period faced recurrent severe droughts and famines. The then Government seemed to have made no systematic efforts in developing agriculture. The adhoc measures adopted were, in fact, the outcome of pressure of events. Besides, the events like World War I, Great Depression and World War II occured during the period which had disastrous effect on agriculture. The condition of agriculture in Uttar Pradesh was in no way different from the agriculture of the entire country. As is evident from Table 1, the yield of all the crops either stagnated or declined significantly during this period. A significantly declining trend was observed in the yields of rice, barley, sugarcane and rapeseed and mustard. Though area expansion under some of the crops like wheat, bajra, sugarcane, sesamum and rapeseed and mustard could increase the production of these crops perceptibly, it

Table 1. Comparison of per annum rate of change for different crops for various time periods

Crop	Area (000 ha)			Yield (kg/ha)			Production (000 tonnes)		
	b_1	b_2	b_3	b_1	b_2	b_3	b_1	b_2	b_3
Rice	0.12	1.55*	1.38*	—0.39*	2.94*	5.97*	—0.34*	5.13*	8.78*
	(0.19)	(0.18)	(0.14)	(0.12)	(0.89)	(0.99)	(0.12)	(1.09)	(1.23)
Wheat	0.55*	0.01*	4.34*	—0.07	1.19	4.27*	0.47*	2.79*	11.66*
	(0.08)	(0.003)	(0.21)	(0.12)	(0.68)	(0.47)	(0.15)	(0.84)	(0.90)
Jowar	1.65**	—0.65*	—1.14*	—0.04	—1.52	0.01	1.48	—2.09*	0.23
	(0.63)	(0.21)	(0.28)	(0.17)	(0.92)	(0.01)	(1.08)	(0.99)	(1.04)
Bajra	3.25*	—0.90*	—0.66*	—0.09	—0.60	1.99	2.53*	—1.38	1.08
	(0.66)	(0.16)	(0.20)	(0.11)	(0.80)	(1.01)	(0.85)	(0.80)	(1.04)
Maize	0.55*	2.27*	—1.31	—0.17	0.04	1.57	0.34	2.83	—0.06
	(0.16)	(0.35)	(0.26)	(0.09)	(0.91)	(1.03)	(0.24)	(1.63)	(0.96)
Barley	0.15	—1.48*	—4.05*	—0.29**	0.09	2.51*	—0.44	—1.15	—2.97*
	(0.26)	(0.30)	(0.34)	(0.11)	(0.53)	(0.46)	(0.42)	(0.64)	(0.44)
Gram	0.62*	0.12	—2.33*	—0.10	1.03	1.76	0.49	1.17	—1.36
	(0.22)	(0.25)	(0.16)	(0.12)	(0.61)	(0.91)	(0.33)	(0.69)	(0.76)
Sesamum	1.41*	3.44*	1.72	—0.02	—0.31	1.38	1.58*	1.84	—1 14
	(0.19)	(0.78)	(0.88)	(0.18)	(0.99)	(2.37)	(0.35)	(10.90)	(1.13)
Rapeseed &	1.35*	3.59*	—1.05	—0.58*	1.78	0.26	0.56**	5.17*	—1.01
Mustard	(0.15)	(0.63)	(0.53)	(0.16)	(0.86)	(0.65)	(0.21)	(1.22)	(0.78)
Sugarcane	1.32*	2.61*	2.46*	—0.90*	1.52	1.33*	2.82*	4.57*	4.32*
	(0.15)	(0.58)	(0.46)	(0.18)	(0.80)	(0.37)	(0.35)	(1.23)	(0.70)

Note : b_i is the estimated slope coefficient in the linear function of time for period i ;=1, 2, 3.

*Significant at 1 per cent level of probability

**Significant at 5 per cent level of probability

failed to increase the production of maize, jowar and gram. The decline in the yield of rice in *kharif* and of barley in *rabi* was so significant that the acreage under these crops could not increase substantially, resulting in decline in the production of rice significantly and the production of barley showed a stagnation. The expansion in area under some of the crops such as wheat, sugarcane and oilseeds was to a considerable extent the consequence of the then Government policies.

During the second period, more area was brought under cultivation in the state through expansion of irrigation facilities and other land reclamation programmes. Emphasis was laid on improving the productivity of land by popularizing improved methods of cultivation of various crops and use of non-conventional inputs like chemical fertilizers. Abolition of *zamindari* system in the state after independence was also a significant event which encouraged private investment in land improvement and thereby increased the land productivity. As a result of adoption of a large number of such measures, acreage under rice, wheat, maize and oilseeds expanded significantly. The highest rate of increase per annum was observed in case of rapeseed and mustard (3590 ha), followed by sesamum (3440 ha), sugarcane (2160 ha) and rice (1550 ha). The acreage under the cereals jowar, bajra and barley declined at varying rates, which was highest for barley (1480 ha per year) and lowest for jowar (650 ha per annum). During the second period, the declining trend in yields was checked to a considerable extent. However, the yields of most of the crops still showed stagnation. Table 1 also reveals that the composite effect of area and yield movements resulted in a significant rate of per annum increase in the output of rice, wheat, rapeseed and mustard and sugarcane crops. The production of jowar underwent a decline.

The state's agriculture entered into a new era of development through greater application of science and technology during the third period. The new farm technology which was introduced in the state during the begining of this period consisted of high yielding varieties of seeds, fertilizer application, water management, pest-control along with good agricultural practices. This technology, through yield increasing effect, increased the output of wheat and rice to a very large extent.

Table 2 indicates that area played a major role relative to yield in increasing or decreasing the output of various crops in Period II over Period I, with the exception of bajra, wherein yield contributed to increased production inspite of fall in the acreage. The Table also reveals that in Period III over Period II the contribution of yield was more relative to area in increasing the output of rice, maize, jowar, bajra and sugarcane. In case of wheat, the area and yield both contributed almost equally. This was because the acreage under wheat also expanded as a result of yield increasing effect of the new technology. For barley, gram, sesamum and

Table 2. Contribution of different sources to change in crop production of various crops

Crop	Contribution of different sources to change in production (%)					
	Period II over Period I			Period III over Period II		
	Change in mean yield	Change in mean area	Interaction between change in mean yield and mean area	Change in mean yield	Change in mean area	Interaction between change in mean yield and mean area
Rice	20.82	69.72	9.46	65.20	17.68	17.12
Wheat	40.90	49.34	9.76	31.82	32.70	35.48
Jowar	4.89	95.47	— 0.36	495.32	—265.89	—129.43
Bajra	190.55	— 73.71	—16.84	128.79	— 19.71	— 9.08
Maize	—664.72	858.91	—94.19	83.40	11.13	5.47
Barley	37.24	67.19	— 4.40	— 3.42	97.64	5.78
Gram	34.36	63.32	2.32	— 94.81	153.02	41.79
Sesamum	—32.18	145.48	—13.28	— 47.28	119.14	28.14
Rapeseed & mustard	— 6.01	109.74	— 3.73	—362.78	364.13	98.65
Sugarcane	7.46	87.45	5.09	53.50	37.58	8.92

Table 3. Period-wise variation in crop output

Crops	Period I		Period II		Period III	
	Mean output (000 tonnes)	MRF*	Mean output (000 tonnes)	MRF*	Mean output (C00 tonnes)	MRF*
Rice	2034	.0860	2583	.0170	4566	.0304
Wheat	2560	.0266	3274	.0161	9854	.0103
Jowar	485	.0801	534	.0379	456	.0646
Bajra	417	.0657	587	.0280	680	.0453
Maize	789	.0311	746	.0368	1130	.0691
Barley	1742	.0424	1572	.0134	1130	.0270
Gram	1598	.0527	1614	.0131	1295	.0402
Sesamum	102	.0628	152	.0563	86	.0292
Rapeseed & mustard	466	.0635	662	.0332	1017	.0380
Sugarcane	1655	.0552	3548	.0281	4881	.0134

*Measure of Relative Fluctuations (MRF) = Variance/mean^2

rapeseed and mustard crops, whose output declined during the third period over the second, the contribution of area was larger.

Fluctuations in Crop Output

The state made striking advances in the production of some of the crops, though the growth in output had been quite uneven and fluctuating over the three periods. The extent of fluctuations varied from crop to crop within a period and also varied from period to period for the same crop (Table 3). The degree of fluctuations depends on the nature of crop production technology—its sensitivity to weather and also to variation in the use of its constituent components dictated by weather, economic environment, availability of material inputs and many other factors. Table 3 revealed that in Period I, the output of rice and jowar showed the highest degree of instability and that of wheat and maize the lowest. As the fluctuations in output are the compounded result of fluctuations in crop acreages and crop yields, area contributed more relative to yield towards fluctuations in rice output and reverse was the case for jowar (Table 4). The magnitudes of instability in the output of all the crops except maize declined during the second period relative to first (Table 3) and the fluctuations in yield of crops were a major source behind this instability (Table 4). Table 3 also reveals that barring a few crops, viz., wheat, sesamum and sugarcane, the instability in the output of crops increased in the third period, though the magnitude of instability remained at a lower level as compared to the first

Table 4. Decomposition of variation in crop production into its components (per cent)

Crops	Variation in crop output due to variation in								
	Area	Yield	Area and yield interaction	Area	Yield	Area and yield interaction	Area	Yield	Area and yield interaction
	Period I			*Period II*			*Period III*		
Rice	74.42	24.07	1.51	5.29	94.70	0.01	3.95	96.04	0.01
Wheat	29.70	69.92	0.38	12.42	87.58	0.00	14.56	85.44	0.00
Jowar	48.19	49.94	1.87	4.48	95.51	0.01	9.29	90.25	0.46
Bajra	70.02	28.61	1.37	2.86	97.14	0.00	5.52	94.26	0.22
Maize	61.74	37.62	0.64	7.61	92.12	0.27	6.95	92.60	0.45
Barley	58.02	41.04	0.94	25.37	74.63	0.00	62.22	37.04	0.74
Gram	64.14	34.72	1.14	15.27	84.73	0.00	5.72	94.03	0.25
Sesamum	33.44	65.29	1.27	30.73	68.03	1.24	17.40	78.62	3.98
Rapeseed & Mustard	25.83	72.91	1.26	27.71	71.69	0.60	43.16	56.05	0.79
Sugarcane	44.46	54.17	1.27	34.88	64.41	0.71	55.22	44.78	0.00

period. In the third period also, yield fluctuations contributed most in the output fluctuations for all the crops with the exception of barley and sugarcane in which area under the crops commanded a larger share (Table 4). Table 1 and 3 together brought out another interesting fact that the output of the two important crops of the state, viz., wheat and sugarcane increased consistently over the three periods with decline in the magnitude of instability in successive periods. The production of rice also increased considerably during the two periods after independence, the rate of increase being higher in the third period, but side by side the instability also increased, behind which the fluctuation in yield was the major factor.

Conclusions

Since the availability of land is limited, increase in output cannot be achieved merely through increase in acreage for long. This study reveals that fluctuations in yield are the major cause for the fluctuations in output and hence the fluctuations in yield have to be controlled to bring in stability in the output. This would mean concerted research efforts in developing such cultivars whose yield potential is stable across different agroclimatic regions. These cultivars have not only to be high yielding even under adverse weather conditions but will also have to be disease and pest-resistant.

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Appendix

DECOMPOSITION OF MRF(P) INTO ITS CONSTITUENTS

Let the area (A) and the yield (Y) of a particular crop in year t be represented by

$$A = \phi(t) + u$$
$$Y = \psi(t) + v \qquad (A.1)$$

where ϕ (t) and ψ (t) are functions of time t and u and v are stochastic disturbances assumed to be statistically independently distributed with

$$E(u)=0=E(v)$$

and

$$E(u^2)=\sigma^2_u,\ E(v^2)=\sigma^2_v \qquad (A.2)$$

Clearly, the output (P) of the crop in year t is

$$P=AY$$

With

$$E(P)=\phi(t)\varphi(t) \qquad (A.3)$$

The variance of the output of the crop under the above assumptions is

$$V(P)=[\psi(t)]^2\ \sigma^2_u+[\phi(t)]^2\ \sigma^2_v+\sigma^2_u\sigma^2_v \qquad (A.4)$$

which when divided by the square of E(P) tn (A.3) yields

$$\frac{V(P)}{E(P)^2} = \frac{\sigma^2_u}{[\phi(t)]^2} + \frac{\sigma^2_v}{[\psi(t)]^2} + \frac{\sigma^2_u}{[\phi(t)]^2}\,\frac{\sigma^2_v}{[\psi(t)]^2}$$

and hence Eq. (3) in the text.