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SPATIAL VARIATIONS, CHANGES AND TRENDS IN AGRICULTURAL EFFICIENCY IN UTTAR PRADESH, 1953-1963*

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During the last decade, considerable efforts have been made to effect improvements in agriculture in different parts of the country. A variety of inputs and incentives have been provided both at the national as well as micro level to promote the growth of agriculture. It would certainly be of interest to agricultural economists and planners to understand the spatial variations in agricultural efficiency and to find out how it has changed over a period of time. A study of the existing and past performance of agriculture is necessary with a view to locating areas that need greater attention in the coming years.

In this paper, an attempt has been made to study agricultural efficiency in Uttar Pradesh from three angles : (*i*) intra-regional variations in agricultural efficiency at a given point of time, (*ii*) changes in agricultural efficiency between two points of time, and (*iii*) trends in agricultural efficiency over a period of time. The period selected for study, as explained below, is the decade from 1953-54 to 1962-63. The 47 plain districts of Uttar Pradesh, extending over nearly 61 million acres, form the study area and easily constitute one of the most highly cultivated parts of India (here, about two-thirds of the total land area is under cultivation and a quarter of it is double cropped). The study area has a diversified cropping pattern and a variety of crops, such as, cereals, millets, pulses, sugarcane, and oilseeds are grown. However, estimates of yield per acre according to crop cutting surveys are available only since 1953-54 for nine crops, namely, rice, wheat, jowar, bajra, barley, maize, gram, *arhar* and sugarcane. As such, data for these crops for the decade 1953-54 to 1962-63 have been used in this study for determining variations, changes and trends in agricultural efficiency as explained in the paragraphs that follow. The yield and acreage data have been obtained from official sources.[1]

MEASUREMENT OF AGRICULTURAL EFFICIENCY

A large number of factors influence the agricultural efficiency of an area. These factors include the physical (*e.g.*, climate, soils), socio-economic (*e.g.*, ownership structure, market environment, size of holding) and technical organizational (*e.g.*, cropping pattern, irrigation facilities, crop rotation). Agricultural efficiency, then, is a function of the combined interplay of a variety of factors that differ from area to area and it manifests itself through per acre productivity as well as volume of production.

Agricultural efficiency may be measured in one of the four ways, namely, as (*i*) output per unit area, (*ii*) output per unit of labour applied, (*iii*) output-input ratio and (*iv*) output in terms of grain equivalents per head of population.

* All of the diagrams in this article were prepared for publication by Shri K. Kumar, Cartographic Assistant in the Department of Human Geography at the University of Delhi. Valuable assistance in checking the data was provided by Shri B. S. Shekhawat.

1. Season and Crop Reports (Annual), Government of Uttar Pradesh, in Hindi, published by Superintendent, Government Press, Lucknow and Allahabad. Data for 1962-63 have been obtained from the Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India, New Delhi.

Necessary data for intra-regional analysis of agricultural efficiency based on (*ii*) and (*iii*) above are not available. Output expressed in terms of grain equivalents was first used by Buck in his study of Chinese agriculture.[2] Buck felt that in a subsistence agricultural economy, like the one prevailing in China then, productivity and volume of production expressed in terms of money did not provide meaningful comparisons. As such, he converted all products into kilograms of grain equivalents according to the "amount of the most usually consumed grain of the locality that the product would buy."[3] Buck's technique was modified by E. de Vries to obtain "milled rice equivalents" per head of population by converting different grains into "rice equivalents" according to local market price of each grain.[4] The procedure has been further refined by Clark and Haswell who have converted the agricultural output to kilograms of wheat equivalent per head of population, using the weighting system employed by the FAO for constructing the international index numbers of agricultural production.[5]

A measure of agricultural efficiency expressed in terms of output per unit area was first evolved by Kendall.[6] He ranked various areal units according to the acre yields of different crops and obtained average rank, called the ranking coefficient, for each unit. Stamp made an international comparison of the agricultural efficiency of twenty countries on the basis of Kendall's method.[7] In India, Shafi made use of the same procedure to measure agricultural efficiency in Uttar Pradesh.[8]

The ranking coefficient of Kendall is somewhat insensitive because of neglect of the areal strength of crops in the cropping pattern in obtaining the average rank. To overcome this weakness, Sapre and Deshpande modified the procedure by taking a weighted average of ranks, the weights in respect of each crop being equal to its proportion in the total cropped acreage of the district.[9] The weighting of ranks still leaves the measure weak because the magnitude of difference in acre-yields is concealed by the ranks. Dandekar has suggested that the weighting of acre-yields rather than the ranks would be more logical and should give a good measure of agricultural efficiency.[10]

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2. John Lossing Buck : Land Utilization in China, University of Nanking, Nanking, 1937; Reproduced by the Council of Economic and Cultural Affairs, Inc., New York, 1956.

3. *Ibid.*, p. 280.

4. Quoted by Colin Clark and Margaret Haswell: The Economics of Subsistence Agriculture, London, 1964, pp. 51-52. In a personal communication to the writer (September 8, 1965), Dr. E. de Vries says that the data on which his comments to Prof. Colin Clark were based, are not easily available due to numerous changes in Indonesian area during the last three decades.

5. *Ibid.*, pp. 57-58.

6. M. G. Kendall, "The Geographical Distribution of Crop Productivity in England," *Journal of the Royal Statistical Society*, Vol. CII, 1939 (New Series), pp. 21-48.

7. L. Dudley Stamp : Our Developing World, London, 1960, pp. 108-109.

8. M. Shafi, "Measurement of Agricultural Efficiency in Uttar Pradesh," *Economic Geography*, Vol. 36, 1960, pp. 296-305.

9. S. G. Sapre and V. D. Deshpande, "Inter-District Variations in Agricultural Efficiency in Maharashtra State," *Indian Journal of Agricultural Economics*, Vol. XIX, No. 1, January-March, 1964, pp. 242-252.

10. V. M. Dandekar, "Rapporteur's Report on Regional Variations in Agricultural Development and Productivity," *Indian Journal of Agricultural Economics*, Vol. XIX, No. 1, January-March, 1964, p. 263. Also see, S. B. Tambad, "Spatial and Temporal Variations in Agricultural Productivity in Mysore State," *Indian Journal of Agricultural Economics*, Vol. XX, No. 4, October-December, 1965, pp. 39-45, and T. R. Rao, "Inter-District Variations in Madras State," *Productivity*, Vol. 6, 1965, pp. 356-363.

It has been shown elsewhere[11] that agricultural efficiency may be regarded as the aggregate performance of various crops expressed through their output per acre but each crop would contribute proportionate to its share of crop land in the cropping pattern. The acre-yields of component units (districts) may be expressed as percentage of the average acre-yield for the entire region (study area) to obtain indexes of yield efficiency for each crop. The yield efficiency indexes may be weighted by the share of crop land devoted to each of the crops. A weighted average of yield efficiency of all crops would provide an index of agricultural efficiency for the component unit in relation to the entire study area.

The above technique may be summarized as below :

$$\text{(i)} \quad I_{y_a} = \frac{Y_c}{Y_r} \cdot 100,$$

where I_{y_a} is the yield index of crop *a*, Y_c is the acre-yield of crop *a* in the component unit, and Y_r is the average acre-yield of crop *a* in the entire study area ;

$$\text{and (ii)} \quad E_i = \frac{I_{y_a} \cdot C_a + I_{y_b} \cdot C_b + \ldots\ldots + I_{y_n} \cdot C_n}{C_a + C_b + \ldots\ldots + C_n},$$

where E_i is the agricultural efficiency index ; I_{y_a}, I_{y_b}, etc., are the yield indexes of various crops ; and C_a , C_b , etc., represent the proportion of crop land devoted to different crops.

MEASUREMENT OF CHANGE AND RATE OF GROWTH OF AGRICULTURAL EFFICIENCY

Using the above technique, and taking nine crops (rice, wheat, jowar, bajra, barley, maize, gram, *arhar* and sugarcane) for which comparable yield and acreage data are available from 1953-54 to 1962-63, agricultural efficiency index (E_i) was calculated for each of the 47 districts for each of the ten years. Three-year moving averages for the agricultural efficiency indexes were then obtained for all the districts.

The average index for the triennium beginning with 1953-54 is taken to represent the agricultural efficiency at the commencement of the decade under study. Likewise, the average index for the triennium ending with 1962-63 represents the agricultural efficiency at the close of the period being studied. Difference in the average efficiency indexes for the first and last triennium of the decade 1953-63 gives change in the efficiency of agriculture for each district.

Further, to find out the annual rate of growth of agricultural efficiency, a linear equation of the type $y=a+bx$ was fitted to the three-year moving averages of the index values for each district. The regression coefficient of each equation represents the slope of the trend line and, therefore, gives the rate of growth of agricultural efficiency for the respective district.

11. Shyam S. Bhatia, "A New Measure of Agricultural Efficiency in Uttar Pradesh," Research Paper, Department of Human Geography, University of Delhi, September, 1965, forthcoming in *Economic Geography*, Clark University, U.S.A.

It may be mentioned here that the calculation of agricultural efficiency indexes based on nine selected crops, for 47 districts for each of the ten years and subsequent computations, like three-year moving averages and fitting of trend lines involved thousands of arithmetical operations. The task would have been too laborious to undertake but for the facility of high speed electronic processing of data at the I.B.M. Computer Center at the University of Delhi.

SPATIAL VARIATIONS IN AGRICULTURAL EFFICIENCY

The average index values for the triennium ending 1962-63 for the 47 districts of Uttar Pradesh were arrayed and divided into two groups on the basis of the regional efficiency index value of 100. Each of the two groups were further subdivided into two halves to obtain four degrees of agricultural efficiency as shown below :

Degree of efficiency	Index value (E_i)
High agricultural efficiency	> 108.9
Medium agricultural efficiency	> 100.0
Low agricultural efficiency	> 91.2
Very Low agricultural efficiency	< 91.2

The agricultural efficiency index for the triennium ending 1962-63 varies in the study area from 76.1 to 120.4 as shown in Table I. Its regional distribution shows that all the northern districts from Deoria in the east to Bijnor in the west (with the exception of Rampur) are below average efficiency. In addition, in the south-west portion, a block formed by Jalaun, Jhansi and Hamirpur districts also shows below average values of agricultural efficiency. The area of very low agricultural efficiency coincides with the *terai* region comprising Basti, Gonda, Bahraich, Kheri, Shahjahanpur, Pilibhit and Moradabad districts. This belt of very low efficiency expands south of Kheri to include the districts of Sitapur and Hardoi and south of Moradabad to include Budaun (Figure 1). Within this area, three contiguous districts, Gonda, Bahraich and Kheri seem to have the lowest values of agricultural efficiency index, with Bahraich showing a value nearly 24 per cent lower than the regional average.

The areas of above average agricultural efficiency are to be found mostly in the Ganga-Yamuna Doab, lower half of Ganga-Gomti Doab and parts of Gomti-Ghaghara Doab. A belt of high agricultural efficiency runs from Agra in the west to Ghazipur in the east through Etawah, Kanpur, Fatehpur, Allahabad, Jaunpur and Varanasi as shown in Figure 1. Among the western districts, Meerut and Bulandshahr show high agricultural efficiency. The district of Dehra Dun also shows a high degree of efficiency. This is interesting in view of the fact that the district has the lowest percentage (about a quarter) of its land under cultivation as against an average of about 66 per cent for the study area. Another small area of high efficiency is formed by Barabanki district which lies at some distance to the north of the main belt.

TABLE I—AGRICULTURAL EFFICIENCY IN UTTAR PRADESH

(average for the triennium ending 1962-63)

District	Index value	District	Index value
High Degree of Efficiency		*Low Degree of Efficiency*	
Dehra Dun	120.4	Jhansi	98.8
Fatehpur	120.2	Mainpuri	98.7
Muzaffarnagar	119.3	Bijnor	98.7
Barabanki	119.1	Azamgarh	97.8
Ghazipur	118.2	Jalaun	97.3
Varanasi	118.2	Bareilly	96.6
Etawah	115.6	Mathura	96.3
Allahabad	114.9	Hamirpur	95.2
Etah	114.5	Gorakhpur	94.9
Agra	114.5	Unnao	93.4
Kanpur	113.2	Deoria	91.2
Meerut	112.6	*Very Low Degree of Efficiency*	
Jaunpur	108.9	Pilibhit	87.8
Medium Degree of Efficiency		Budaun	87.6
Pratapgarh	108.4	Basti	86.9
Farrukhabad	107.9	Moradabad	85.3
Faizabad	107.1	Shahjahanpur	83.9
Rae Bareli	106.9	Sitapur	83.0
Sultanpur	106.1	Hardoi	82.4
Aligarh	105.6	Gonda	80.8
Bulandshahr	105.3	Kheri	79.4
Mirzapur	105.1	Bahraich	76.1
Rampur	104.4		
Lucknow	104.3		
Banda	103.3		
Saharanpur	101.3		
Ballia	101.1		

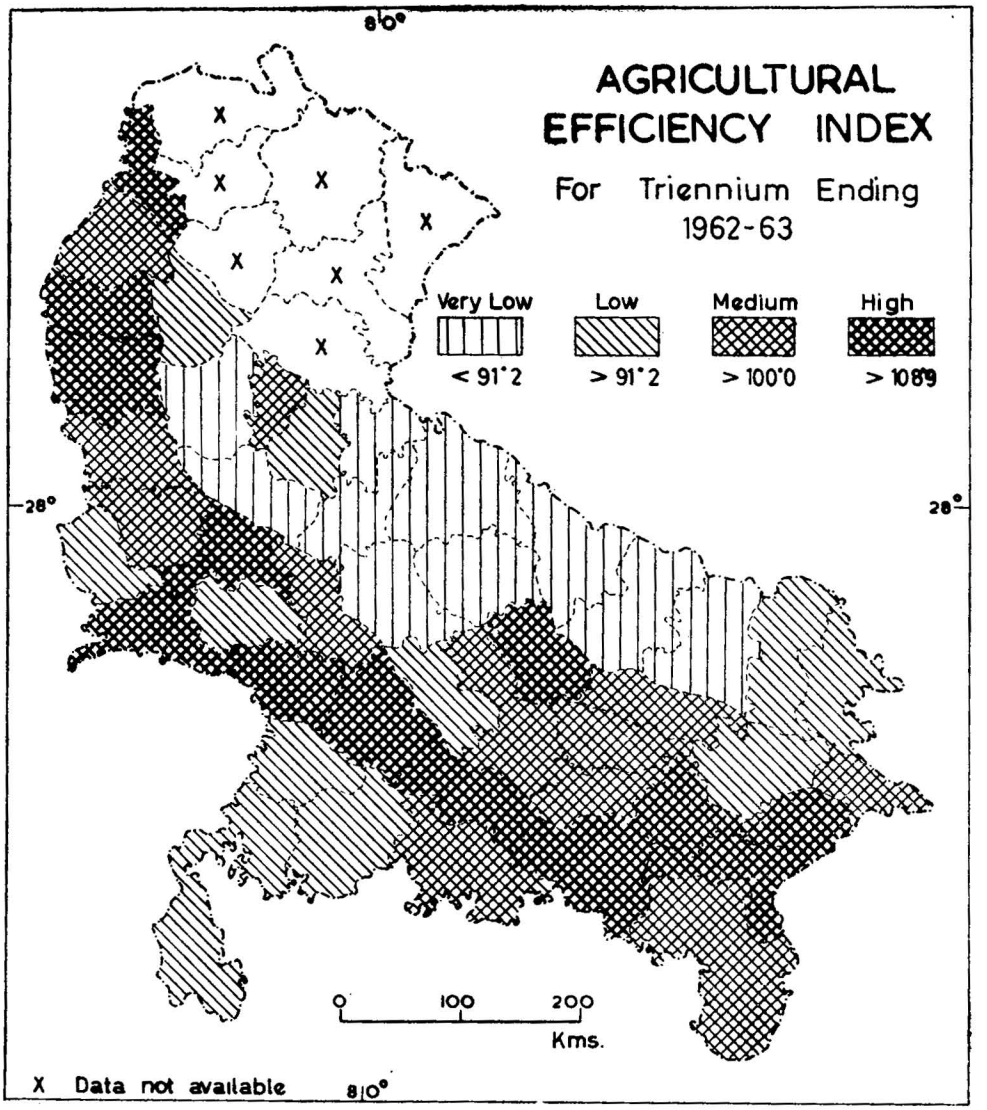

Figure 1.

Unlike the high and very low efficiency zones formed by contiguous districts, medium and low efficiency districts occur in small patches more or less in a scattered form. A small block of medium efficiency occurs in east central section of the study area and comprises Faizabad, Sultanpur, Pratapgrah, Rae Bareli and Lucknow districts. Likewise, a low density block occurs in the north-east comprising Deoria, Gorakhpur and Azamgarh.

In contrast to the above, the agricultural efficiency during the triennium starting with 1953-54 shows a different spatial pattern though the lowest and highest index values are not any different. The index values range from 78.5 in Bahraich

to 119.5 in Etawah as shown in Table II. In terms of intra-regional comparison, the area having below average efficiency appears to be very large. All the northern districts from Deoria in the east to Dehra Dun in the west show below average efficiency. But, the area of very low agricultural efficiency does not occur as a continuous belt. Instead, it occurs in small patches of one or two districts each (Figure 2).

TABLE II—AGRICULTURAL EFFICIENCY IN UTTAR PRADESH

(average for the triennium beginning 1953-54)

District	Index value	District	Index value
High Degree of Efficiency:		*Low Degree of Efficiency:*	
Etawah	119.5	Faizabad	99.5
Fatehpur	118.2	Ghazipur	99.4
Mainpuri	117.6	Mirzapur	99.0
Meerut	114.8	Saharanpur	98.7
Agra	114.8	Mathura	98.6
Bulandshahr	114.3	Ballia	98.3
Barabanki	112.0	Sultanpur	97.6
Muzaffarnagar	111.5	Gorakhpur	97.5
Pratapgarh	109.9	Lucknow	96.6
Aligarh	109.7	Hardoi	96.3
Hamirpur	109.3	Bijnor	95.9
		Unnao	95.3
Medium Degree of Efficiency:		Dehra Dun	95.2
Kanpur	108.6	Basti	93.7
Etah	108.0	Budaun	93.7
Jhansi	104.8	Kheri	92.5
Banda	104.2	Azamgarh	92.4
Allahabad	103.1	Rampur	92.2
Rae Bareli	102.9	Bareilly	92.2
Farrukhabad	102.2	*Very Low Degree of Efficiency:*	
Sitapur	100.4	Pilibhit	91.1
Jaunpur	100.3	Deoria	88.7
Varanasi	100.1	Shahjahanpur	88.3
		Gonda	87.2
		Jalaun	86.4
		Moradabad	85.4
		Bahraich	78.5

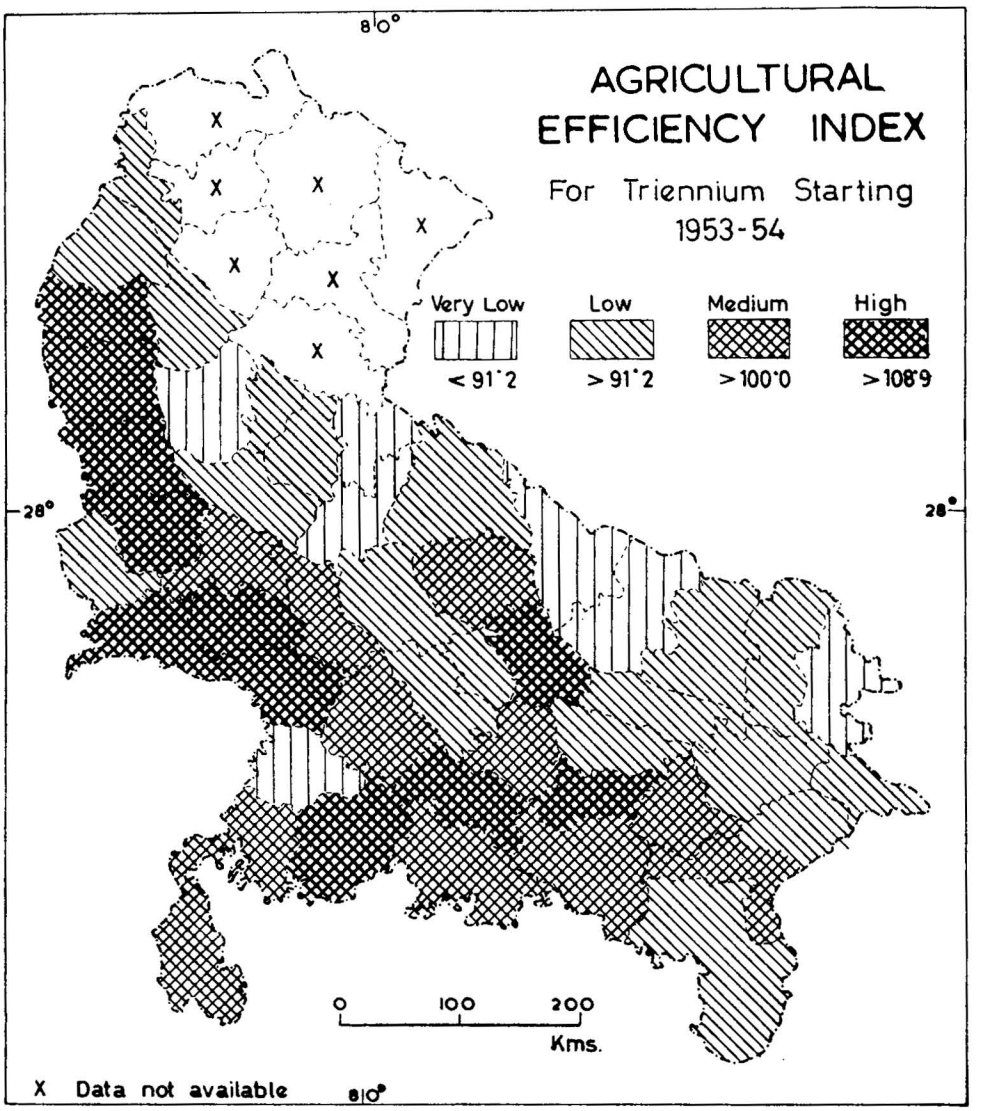

Figure 2.

The area with above average efficiency lies mostly in the western and southern parts of Uttar Pradesh. Within it, the area of high agricultural efficiency forms an almost continuous belt from Muzaffarnagar to Agra through Meerut, Bulandshahr and Aligarh. Thence, it expands to include Mainpuri and Etawah. A smaller part of this high efficiency area lies further eastward and comprises the districts of Hamirpur, Fatehpur and Pratapgarh. An isolated extension of this area also occurs in the mid-central part of Uttar Pradesh and is formed by Barabanki district.

PATTERN OF CHANGE

A comparison of agricultural efficiency indexes for the first and the last triennium of the decade gives the amount of change in agricultural efficiency for each district. The amount of change shows a wide range from an increase of 25.2 to a decrease of 18.9 in index value as shown in Table III. An analysis of change shows that among the districts where improvement of agricultural efficiency took place, as many as eight districts gained between 1 to 5, ten districts gained between 5 to 10, and six districts gained by more than 10 in index value. On the contrary, among the districts which show a decrease in agricultural efficiency, three districts declined by less than 1, ten districts declined between 1 to 5, five districts declined between 5 to 10, and five districts declined by more than 10 in index value.

TABLE III—CHANGE IN AGRICULTURAL EFFICIENCY INDEX BETWEEN 1953-56 AND 1960-63

Districts showing increase		Districts showing decrease	
Increase > 10.0		Decrease < − 10.0	
Dehra Dun	25.2	Moradabad	— 0.1
Ghazipur	18.8	Agra	— 0.3
Varanasi	18.1	Banda	— 0.9
Rampur	12.2	Pratapgarh	— 1.5
Allahabad	11.8	Unnao	— 1.9
Jalaun	10.9	Meerut	— 2.2
		Mathura	— 2.3
Increase < 10.0		Bahraich	— 2.4
Jaunpur	8.6	Gorakhpur	— 2.6
Sultanpur	8.5	Pilibhit	— 3.3
Muzaffarnagar	7.8	Etawah	— 3.9
Lucknow	7.6	Aligarh	— 4.1
Barabanki	7.1	Shahjahanpur	— 4.4
Etah	6.5	Jhansi	— 6.0
Mirzapur	6.1	Budaun	— 6.1
Farrukhabad	5.9	Gonda	— 6.4
Azamgarh	5.4	Basti	— 6.8
Kanpur	4.6	Bulandshahr	— 9.0
Bareilly	4.4	Decrease > − 10.0	
Ballia	2.8	Kheri	—13.1
Bijnor	2.8	Hardoi	—13.9
Saharanpur	2.6	Hamirpur	—14.1
Deoria	2.5	Sitapur	—17.4
Fatehpur	2.0	Mainpuri	—18.9

The spatial distribution of change shows that the districts where agricultural efficiency has improved lie generally in eastern to south-eastern, central and north-western parts of Uttar Pradesh (Figure 3). A large block extending from Deoria in the north-east to Mirzapur in the south-east reaching as far as Lucknow, Kanpur and Jalaun (with the exception of Unnao and Pratapgarh) shows improvement in efficiency. Within this block, three contiguous districts of Allahabad, Varanasi and Ghazipur stand out for considerable increase in agricultural efficiency. In the north-west, a smaller block comprising districts of Muzaffarnagar, Bijnor, Saharanpur and Dehra Dun also shows gain in efficiency. Likewise, another patch formed by Rampur and Bareilly shows increase of agricultural efficiency.

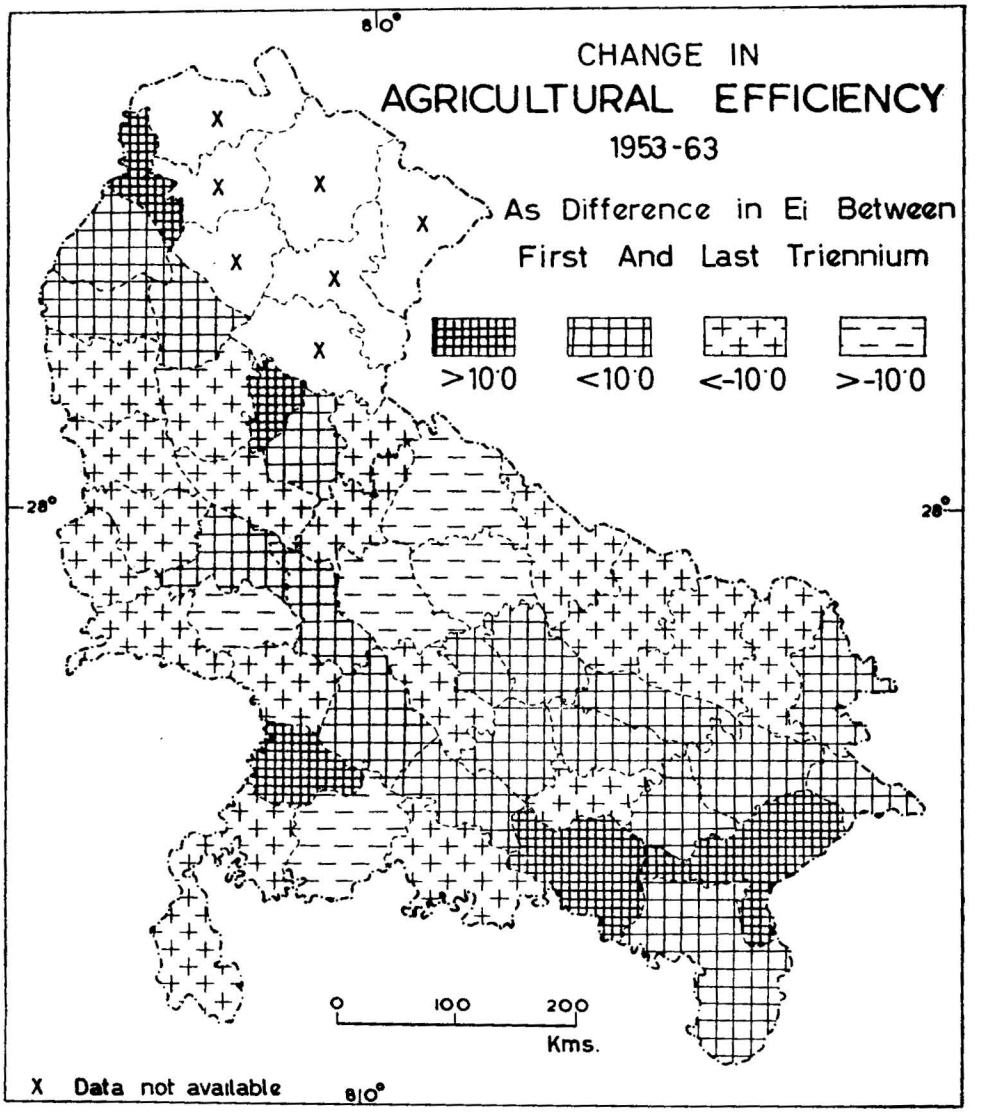

Figure 3.

Interestingly, the districts of Ghazipur and Dehra Dun which showed below average efficiency for the triennium 1953-56, seem to have gained to such an extent that both of them appear as high efficiency areas during the triennium 1960-63 (*Cf.* Figures 1, 2 and 3). In contrast to this, Mainpuri and Hamirpur which showed high agricultural efficiency at the beginning of the decade, declined considerably (18.9 and 14.1 respectively in index value) and both show low efficiency during the triennium 1960-63 (*Cf.* Figures 1 and 2 with Table III). Four other districts, Rampur, Allahabad, Varanasi and Jalaun showed an increase of more than ten in index value during the decade. As opposed to this, a block of three districts comprising Kheri, Sitapur and Hardoi showed a decline of more than ten in index value during the decade resulting in very low efficiency for the triennium 1960-63.

TRENDS IN AGRICULTURAL EFFICIENCY

As noted earlier, the linear rate of growth of agricultural efficiency has been determined by fitting trend lines to the three-year moving averages of the index values for each district. Trend lines in respect of five districts with contrasting rates of growth of agricultural efficiency have been shown in Figure 4. The regression coefficients for various districts show that the annual rate of growth of agricultural efficiency varies from 4.42 in Ghazipur to minus 3.20 in Sitapur. Further, in as many as eight districts, the annual rate of growth (positive or negative) is less than 0.25, the rate being nil in Pratapgarh. In Bahraich, Pilibhi, Moradabad and Farrukhabad, the rate is less than minus 0.25 while in Gorakhpur, Deoria, Kanpur and Meerut, it is less than 0.25. In contrast to this, four districts show a growth rate of higher than 2.0 while in five districts the rate of decline is equally high (Table IV).

Spatial variations in the linear rate of growth of agricultural efficiency show that in eastern, southern, central and north-western sections of Uttar Pradesh, the trend has been towards an increase in agricultural efficiency(Figure 5). Within this large area, the south-eastern districts have a rather high rate of growth. Likewise, Dehra Dun, Muzaffarnagar, Bijnor and Rampur also have a high rate of growth. In contrast to the foregoing, all the northern districts from Basti in the east to Pilibhit in the west, and the south-western districts from Bulandshahr to Etawah show a declining trend in agricultural efficiency. The districts of Kheri, Sitapur, Hardoi, Mainpuri and Hamirpur show a high rate of decline.

Generally speaking, the spatial changes in agricultural efficiency as shown by the difference in index values for the first and the last triennium of the decade are more or less in accord with the distributional pattern of growth rates of agricultural efficiency (*Cf.* Figures 3 and 5). A study of the intra-regional variations in the rate of growth of agricultural efficiency clearly brings out the areas that need greater attention during the coming years. The areas which have very low agricultural efficiency and show a declining trend in it, particularly deserve special treatment. Such areas comprise the northern districts of Basti, Gonda, Bahraich, Kheri, Pilibhit, Shahjahanpur, Hardoi, Sitapur, Budaun and Moradabad (*Cf.* Figures 1 and 5).

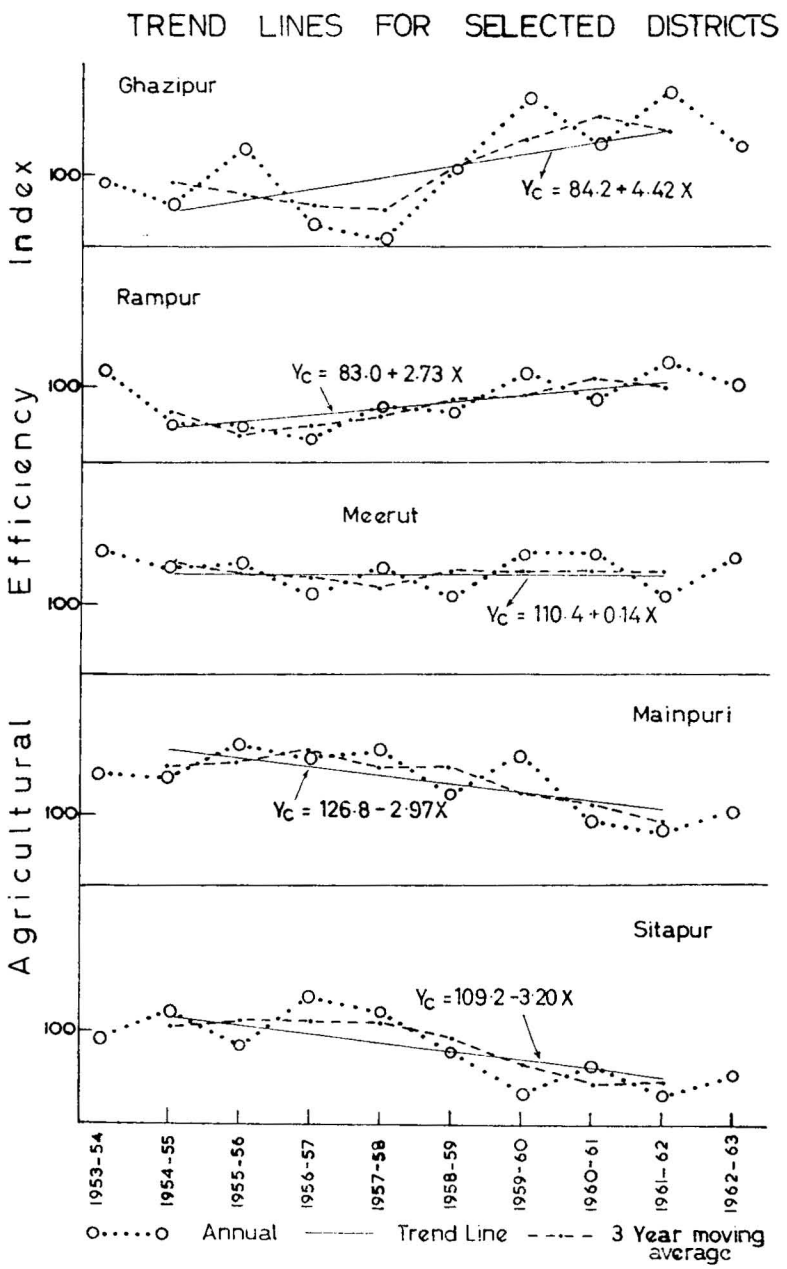
TREND LINES FOR SELECTED DISTRICTS
Agricultural Efficiency Index
Ghazipur
Yc = 84·2 + 4·42 X
Rampur
Yc = 83·0 + 2·73 X
Meerut
Yc = 110·4 + 0·14 X
Mainpuri
Yc = 126·8 - 2·97X
Sitapur
Yc = 109·2 - 3·20 X
100
1953-54
1954-55
1955-56
1956-57
1957-58
1958-59
1959-60
1960-61
1961-62
1962-63
Annual
Trend Line
3 Year moving average

Figure 4.

TABLE IV—LINEAR RATE OF GROWTH OF AGRICULTURAL EFFICIENCY: 1953-63

Districts showing increase		Districts showing decline	
District	Rate	District	Rate
Ghazipur	4.42	Sitapur	—3.20
Dehra Dun	3.64	Mainpuri	—2.97
Rampur	2.73	Hamirpur	—2.83
Varanasi	2.68	Kheri	—2.74
Muzaffarnagar	1.84	Hardoi	—2.56
Jalaun	1.79	Aligarh	—1.41
Banda	1.73	Etawah	—1.30
Mirzapur	1.41	Bulandshahr	—1.17
Jaunpur	1.35	Gonda	—0.98
Bijnor	1.31	Mathura	—0.91
Allahabad	1.20	Agra	—0.77
Sultanpur	1.18	Basti	—0.76
Azamgarh	0.95	Jhansi	—0.75
Bareilly	0.94	Unnao	—0.67
Rae Bareli	0.93	Shahjahanpur	—0.46
Lucknow	0.74	Budaun	—0.27
Barabanki	0.63	Farrukhabad	—0.18
Faizabad	0.54	Pilibhit	—0.10
Etah	0.51	Moradabad	—0.07
Ballia	0.36	Bahraich	—0.04
Saharanpur	0.33		
Fatehpur	0.33		
Deoria	0.22	Pratapgarh	nil
Gorakhpur	0.15		
Meerut	0.14		
Kanpur	0.02		

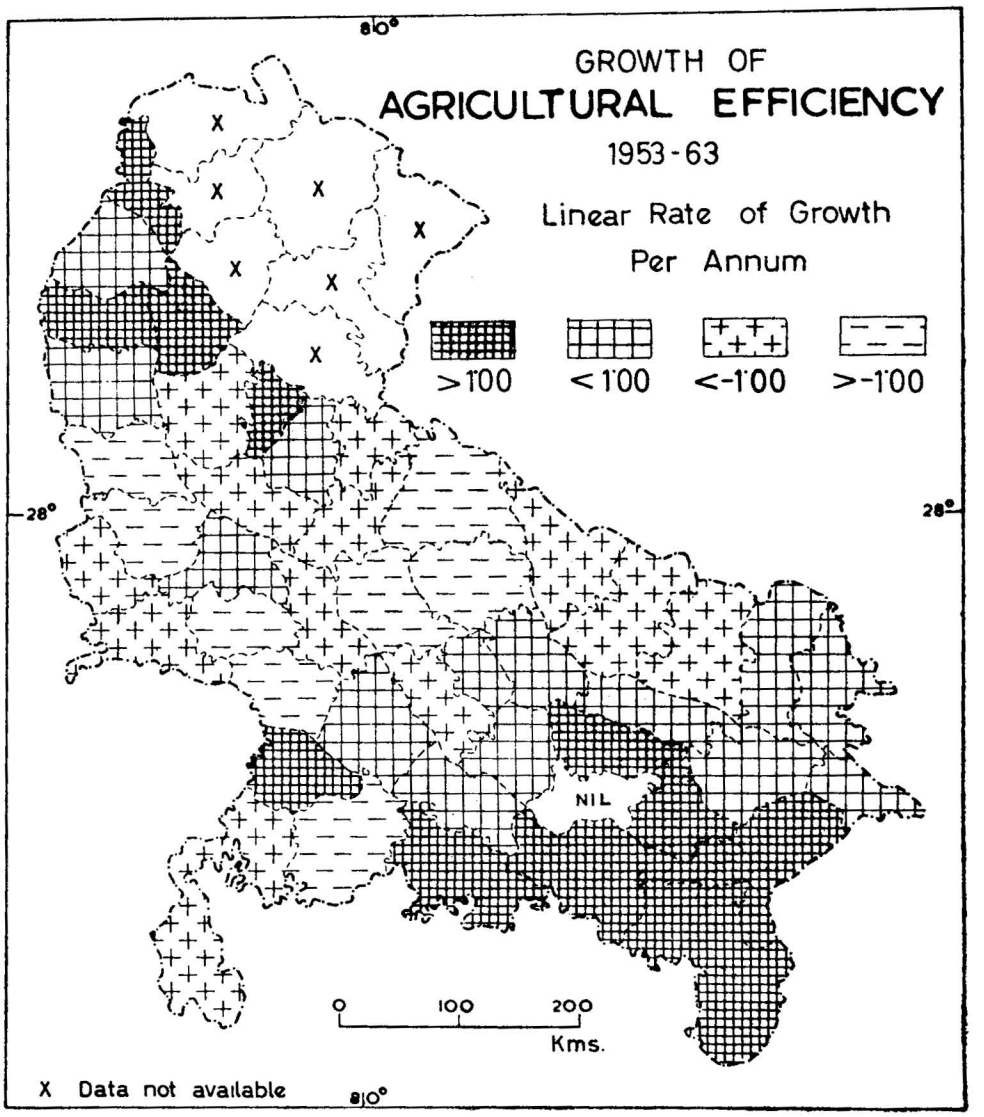

Figure 5.

CONCLUSIONS

In this paper, agricultural efficiency index for various districts of Uttar Pradesh has been calculated by expressing the yield of nine selected crops as percentage of the corresponding average yield in the entire study area and then taking their weighted average, the weights being proportionate to the strength of crop land devoted to various crops. The indexes of agricultural efficiency were calculated for each of the ten years from 1953-54 to 1962-63 and three-year moving averages

obtained. The change in agricultural efficiency has been computed by taking the difference between the average of first and last triennium of the decade and its spatial pattern has been discussed. Further, by fitting trend lines to the three-year moving averages of the index value for each district, the linear rates of growth of agricultural efficiency have been calculated with a view to differentiating areas that may have been gaining or losing in agricultural efficiency during the decade under study. No attempt has been made here to determine reasons for differences in the rates of growth of agricultural efficiency. The multiplicity of factors with which the efficiency of agriculture is associated, makes it rather difficult and complicated to assess the causes for failure of performance in any area. However, further work is needed to identify at least some of the determinants of agricultural efficiency in different parts of Uttar Pradesh.