

USE OF MULTIVARIATE CORRELATION ANALYSIS IN THE STUDY OF LAND USE IN DISTRICT MEERUT, UTTAR PRADESH

SURENDRA SINGH AND V. S. CHAUHAN

As attempted by Kendall (1957), Berry (1958), Lawley & Maxwell (1963), Haggett (1964), and Cole and Smith (1965) there are not many studies aiming at multiple factor analysis in the field of geography and much less in India where Learmonth and Bhat (1961), Rao (1962) and Pal (1963) have applied these techniques usefully.¹ There is, therefore, need for many more exercises and attempts for testing its worth. In this paper, while studying land use, an effort has been made to find correlations quantitatively between some prominent natural and human factors.

District Meerut (28° 35'N to 29° 15'N lat. and 77° 10'E to 78° 5'E long.) lies in an agriculturally advanced part of Uttar Pradesh in between the Ganga and Yamuna rivers (Fig.1). The area slopes very gently from 775 feet above sea level in the north to 680 feet in the south. The gradient amounts to less than 2 feet per mile. Beside the two rivers, Ganga and Yamuna making eastern and western boundaries, there are

-
1. M. G. Kendall, *A Course in Multivariate Analysis*, London (1957); B.J.L. Berry, *Shopping Centres and the Geography of Urban Areas*, University of Washington, Ph. D. Thesis (1958); D. N. Lawley and A. E. Maxwell, *Factor Analysis as a Statistical Method*, London (1963), pp. 2-3; P. Haggett, 'Regional and Local Components in the Distribution of Forested Areas in South-East Brazil: A Multivariate Approach', *Geog. Jour.* Vol. 130 (1964), pp. 365-80; J. P. Cole and G. A. Smith, 'France: a Rank Correlation Project', *Bull. of Quantitative Mater. Geog.*, (1965), University of Nottingham; A.T.A. Learmonth and L. S. Bhat, 'Pilot Regional Survey of the Mysore State', *Atlas of Resources*, Indian Statistical Institute (1961); V.L.S.P. Rao, 'Rational Grouping of the Districts of Madras State,' *Indian Geog. Mag.*, Bombay (1962); M. N. Pal, 'A Method of Regional Analysis of Economic Development with special reference to South India', *Jour. of Regional Soc.*, Philadelphia (1963), pp. 41-58.

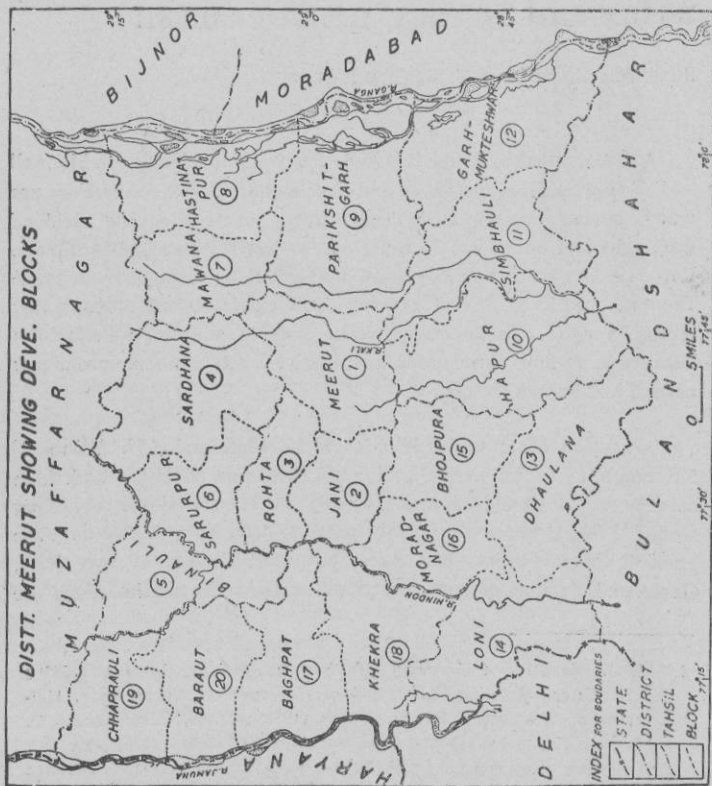


Fig. 1

their tributaries like Hindon and Kali draining the middle part of the district. There is, of course, a larger area under new alluvium (*khadar*) along the river Ganga than along the Yamuna.² Typical monsoon type of climate prevails. Amount of rainfall experienced annually is about 28 inches at the district headquarters, but 90 per cent of the cropped area depends upon irrigation from canals (Upper Ganga and Anupshahar Branch) and tubewells.³ The water-table is higher (about 6 feet) in the Ganga *khadar* than in the Yamuna *khadar* area and gradually lowers down (7-10 feet) in the middle part of the district.⁴

The study has three-fold objectives : firstly, it is to evaluate correlations among the chief factors of land use ; secondly, to trace the influence of the factors; and thirdly, to analyse the dispersion of main factors and their significance in the land use of district Meerut. The Community Development Blocks have been taken as areal units. There are 20 blocks in district Meerut (Fig. 1). In each block there are about 60 to 70 villages.

For correlation analysis sixteen important factors have been chosen, which may be clustered into the following three groups : (i) The physical group consists of five factors of area, gradient, water-table, rainfall and soil. The fifth factor of soil has been divided into five sub-factors on the basis of fertility elements like hydrogen content, total soluble salts, phosphates, potash and nitrogen. (ii) The agricultural group pertains to five factors again; these being Gross Cultivated Area (GCA), irrigated area, wheat area, sugarcane area and maize area. (iii) Lastly, the population group comprises two significant factors of density of total population and density of agricultural population (Table I).

Correlations among the factors

To find out the coefficient of correlations among the above

-
2. Survey of India Topo. sheet Nos: 53G/4, G/12, G/16, 53H/I, H/5, H/6, H/9, H/10, 53K/4, 53L/2.
 3. Majid Husain, 'Agricultural Land Use in Meerut Distt.' *The Geographical Observer*, Vol. 5 (1969), pp. 110-14.
 4. R.N. Mathur; 'A Study in Ground Water Hydrology of the Meerut Distt., U.P., (1969).

sixteen factors as many as 256 inter-correlations are likely to mature. It would be difficult task to present such relations through different maps by their super-imposition. It is, therefore, suggested to use Carl Pearson's coefficient of correlation Product Moment formula⁵ for the evaluation of such correlations. Cramer's symmetric matrix⁶ composed from the above technique denotes the following inter-correlations among the causal variables (Table II A and B) :

(1) The GCA attains the highest place (+0.91) and second place is enjoyed by maize area (+0.67). Naturally, with the increase in block size the area under gross cultivation and maize have increased simultaneously. On the other hand there is perceptible negative effect upon density of total population (-0.41). In other words with the increase of blocks' area both the type of densities in population have decreased.

(2) The gradient of slope is bringing positive effect upon wheat (+0.31) and maize (+0.30). The more slopy areas are not preferred for sugarcane cultivation (-0.30). The population density is also less here.

(3) The areas of lower water-table have attracted more areas under gross cultivation (+0.43) and irrigation (+0.42). On the other hand with the increase in water-table the fertility contents of nitrogen (-0.60) and total soluble salts (-0.31) have decreased.

(4) The areas receiving higher rainfall have positively affected the pH value in the soils (+0.35) and water-table (+0.22), and the areas under irrigation (-0.53) and wheat (-0.50) have been affected negatively.

(5) With the increase of soluble salts' content in the soils, there

5. Simpson and Kafka, *Basic Statistics*, (1969), p. 368—Coeff. correlation formula

$$\text{by Carl Pearson } r = \frac{\sum x \cdot y}{\sqrt{\sum x^2 \cdot \sum y^2}}, \quad x = (x - \bar{x}), \quad y = (y - \bar{y})$$

(r —coeff. of correlation, x —first factor's deviation from the mean and y —other factors' deviation from the mean)

6. Cramer, *c. f.* Quinn Mc-Memer, *Psychological Statistics* (1962), p. 198.

TABLE I

I

Physical Group

Block-Names ↓	Items →	Soil Fertility Groups								
		V ₁	V ₂	V ₃	V ₄	V ₅	V ₆	V ₇	V ₈	V ₉
		V _n	V ₂	V ₃	V ₄	V ₅	V ₆	V ₇	V ₈	V ₉
		A _n								
			(in ,000 hect.)	(in ft.)	(in inches)	(in %)	(in %)	(in Lbs/acre)	(in Lbs/acre)	(in %)
			Slope Gradient	Water Table	Rainfall	pH (Normal)	T.S.S. (Normal)	P ₂ O ₅ (Medium)	K ₂ O (Medium)	O/C (highest)
			(on 1000)							
Meerut	A ₁	30.2	29.0	17.0	40.0	87.0	95.0	12.0	7.0	5.0
Jani	A ₂	19.8	28.0	13.0	40.0	83.0	90.0	14.0	10.0	4.0
Rohata	A ₃	18.5	17.0	13.0	40.0	81.0	89.0	10.0	1.0	4.0
Sardhana	A ₄	38.7	49.0	15.0	29.0	91.0	95.0	13.0	42.0	6.0
Binauli	A ₅	29.5	32.0	40.0	29.0	87.0	91.0	10.0	12.0	1.0
Sarurpur	A ₆	20.1	45.0	13.0	29.0	97.0	98.0	13.0	11.0	5.0
Mawana	A ₇	24.6	50.0	15.0	34.0	97.0	99.0	10.0	5.0	7.0
Hastinapur	A ₈	34.6	19.0	10.0	34.0	89.0	91.0	12.0	6.0	6.0

Parikshitgarh	A ₉	47.6	46.0	12.0	34.0	98.0	98.0	7.0	10.0	3.0
Hapur	A ₁₀	38.0	53.0	22.0	27.0	91.0	98.0	10.0	8.0	2.0
Simbhavli	A ₁₁	36.3	58.0	12.0	27.0	93.0	94.0	16.0	0.0	6.0
Garhmukteshwar	A ₁₂	33.4	37.0	18.0	27.0	96.0	96.0	18.0	14.0	8.0
Dhaulana	A ₁₃	32.6	80.0	17.0	23.0	82.0	92.0	18.0	10.0	4.0
Loni	A ₁₄	28.2	120.0	21.0	23.0	87.0	90.0	14.0	7.0	2.0
Bhojpura	A ₁₅	26.5	18.0	14.0	23.0	86.0	97.0	10.0	11.0	4.0
Murad-Nagar	A ₁₆	24.4	17.0	9.0	23.0	89.0	98.0	11.0	5.0	3.0
Baghpat	A ₁₇	27.4	41.0	28.0	24.0	88.0	91.0	15.0	7.0	4.0
Khekra	A ₁₈	32.2	47.0	28.0	24.0	86.0	89.0	17.0	8.0	5.0
Chhaprauli	A ₁₉	19.6	35.0	15.0	24.0	88.0	93.0	10.0	5.0	4.0
Barout	A ₂₀	22.3	37.0	18.0	24.0	88.0	80.0	9.0	2.0	6.0



Table 1 contd.

Block-Names ↓	II Agricultural Group				III Population Group			
	Items ↑	V_{10}	V_{11}	V_{12}	V_{13}	V_{14}	V_{15}	V_{16}
	Total Gross Cultivated Area (in 1000 hect.)	Total Irrigated Area (in 1000 hect.)	Total Wheat Area (in 1000 hect.)	Total Sugarcane Area (in 1000 hect.)	Total Maize Area (in 1000 hect.)	Density of Population (per hect.)	Density of Agricultural Population (per hect.)	
Meerut	35.8	21.0	8.5	6.8	2.8	3.5	0.6	
Jani	14.2	12.2	4.6	5.4	1.4	4.5	0.7	
Rohata	21.6	10.8	3.8	5.3	1.3	4.0	0.6	
Sardhana	42.6	27.4	12.6	11.0	2.3	3.8	0.3	
Binaulti	35.6	24.9	11.2	9.0	3.2	4.0	0.9	
Sarurpur	23.9	11.4	6.4	4.4	2.5	3.8	0.8	
Mawana	27.6	9.8	6.9	7.6	0.3	3.3	0.7	
Hastinapur	31.7	6.8	9.3	8.2	0.3	1.6	0.4	

Parikshitgarh	A ₉	49.4	9.9	1.2	4.0	4.7	3.8	0.7
Hapur	A ₁₀	50.6	37.8	11.6	6.3	7.6	3.1	0.8
Simbhavli	A ₁₁	50.3	26.4	16.6	7.0	6.1	4.0	0.9
Garhmukteshwar	A ₁₂	33.5	0.0	5.9	3.6	2.5	2.6	0.6
Dhaulana	A ₁₃	40.0	33.3	11.8	7.1	5.9	3.6	0.6
Loni	A ₁₄	26.6	11.2	9.8	0.9	1.4	3.3	0.8
Bhojpora	A ₁₅	30.7	17.2	7.7	4.7	2.3	3.8	0.9
Murad-Nagar	A ₁₆	31.8	18.4	7.7	4.6	2.6	4.0	1.0
Baghpat	A ₁₇	32.6	27.7	10.8	7.1	2.3	4.2	1.0
Khekra	A ₁₈	40.0	23.9	12.8	5.5	5.3	4.0	0.6
Chhaprauli	A ₁₉	23.7	16.0	7.8	6.7	1.0	5.3	0.9
Barout	A ₂₀	27.3	25.4	9.1	8.0	0.9	4.8	0.9

TABLE II (A)
Coefficient Correlation, Symmetric Matrix—(Product Moment 'r' by Carl Pearson)

V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	Total	%	Rank	
V_1	100	28	07	06	06	37	05	41	07	91	28	09	18	67	41	10	401	7.7	5
V_2	28	100	23	18	12	05	32	18	15	20	19	31	30	30	07	01	289	6.0	10
V_3	07	23	100	22	34	31	10	05	60	43	42	40	21	28	18	00	384	7.3	6
V_4	06	18	22	100	35	09	30	04	10	21	53	50	08	24	38	28	356	6.9	7
V_5	06	12	34	35	100	37	03	19	25	10	29	28	05	16	11	03	273	5.2	11
V_6	37	05	31	09	37	100	05	23	02	29	10	10	09	38	20	00	265	5.0	12
V_7	05	32	10	30	03	05	100	20	30	06	23	37	14	12	12	00	239	4.6	14
V_8	41	18	05	04	19	23	20	100	06	31	21	21	43	04	10	40	306	6.0	9
V_9	07	15	60	10	25	02	30	06	100	02	12	04	10	19	35	00	237	4.4	15
V_{10}	91	20	43	21	10	29	06	31	02	100	56	40	08	68	12	04	441	8.6	2
V_{11}	28	19	42	53	29	10	23	12	56	100	67	58	75	17	12	522	10.0	1	
V_{12}	09	31	40	50	28	10	37	21	40	67	100	53	28	00	00	418	8.2	4	
V_{13}	18	30	21	08	05	09	14	43	10	08	58	100	13	22	00	312	6.0	8	

V_{14}	67	30	28	24	16	38	12	04	19	68	75	28	13	100	00	00	422	8.2	3
V_{15}	41	07	18	38	11	20	12	10	35	12	17	00	22	00	100	00	243	4.6	13
V_{16}	10	01	00	28	03	00	00	40	00	04	12	00	00	00	00	100	98	1.3	16
																	5206	100.0	

Note : (1) The figures are multiplied by 100 and negative correlation coefficients are shown in italics.
 (2) The total of rows are ignoring the minus sign and 100 figures.

TABLE II (B)

Coefficient Correlation Symmetric Matrix—
(Product Moment 'r' by Carl Pearson)

Rank Order	%	Cumulative %
1	10.0	10.0
2	8.6	18.6
3	8.2	26.8
4	8.2	35.0
5	7.7	42.7
6	7.3	50.0
7	6.9	56.9
8	6.0	62.9
9	6.0	68.9
10	6.0	74.9
11	5.2	80.1
12	5.0	85.2
13	4.6	89.7
14	4.6	94.3
15	4.4	98.7
16	1.3	100.0

has been increase in maize area (- 0.38) and GCA. High phosphate content in the soil has attracted the wheat cultivation (+0.37). Nitrogen finds second place to phosphates in this respect. High potash content in the soil is more favoured by sugarcane (+0.43), whereas the density of population has decreased (-0.40). But the areas of high nitrogen content in the soil are favoured by total population at large.

(6) Increase in GCA finds positive correlation with maize (+0.75), irrigation (+0.56) and wheat (+0.40). It depicts that maize cultivation receives attention only when GCA is much, otherwise only wheat cultivation is preferred.

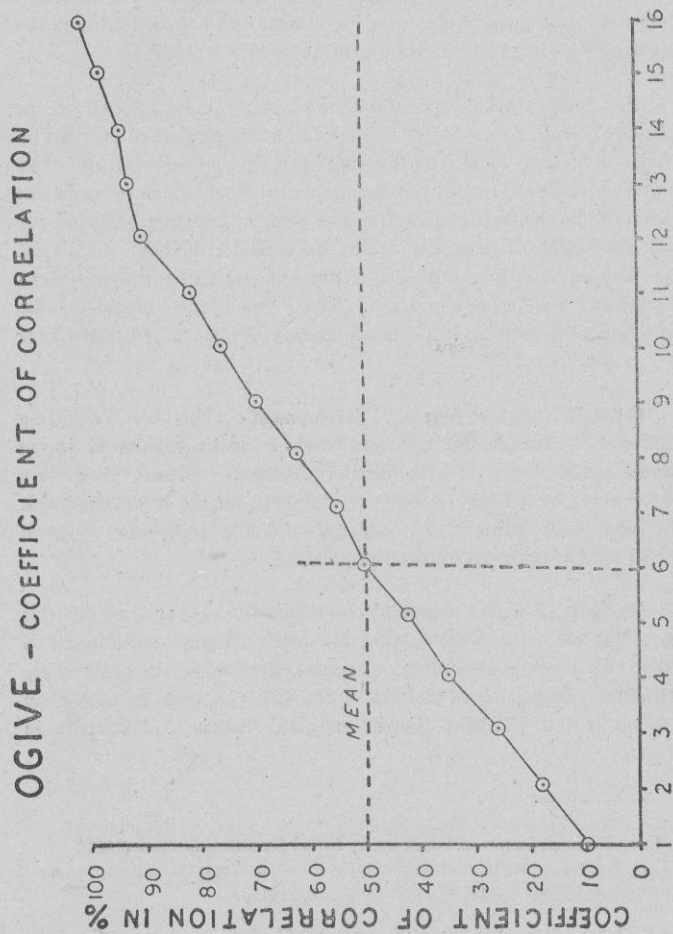
(7) Wheat and sugarcane are positively correlated with each other, i.e. wherever wheat area is much, sugarcane area is also much. But sugarcane area has negatively affected the density of population (-0.22).

Force of Individual Factors

The above study exclusively pertains to inter-correlations among the chosen sixteen factors without assessing their individual force or significance among the lot. Now an effort can be made to trace the force of individual factors. The same coefficient correlation matrix may be helpful for this purpose also by adding the rows of sixteen variables. "The higher the value, the more generally related is the variable." Further, the percentage of individual factors can be calculated out of the total to assess their significant force or weightage. After putting their values in ranking order it is found that six factors namely irrigation, gross cultivated area, wheat area, maize area, total block area and water-table assume the highest force among the sixteen, attributing 50 per cent of the total (Table IIb). The significant results can be displayed by an Ogive (Fig. 2).

Dispersion of main factors and their significance

For an areal study of the significant level of the main factors in district Meerut those six carrying 50 per cent force may be accounted for. It will show the degree of development for each block. Lesser the



RANKING OF VARIABLES
Fig. 2

dispersion of factors' force, greater is the degree of development. A similar study was made by Indian Statistical Institute to identify relatively developed and under-developed areas applying a different quantitative technique.⁸ Pal tried to assess regional disparities in the levels of development in the country of India as a whole.⁹

For analysing the dispersion of these six prominent factors in the blocks coefficient of variations¹⁰ are helpful, which may be categorised on the basis of ranking coefficient of variation of the six main factors. The mean of variation (60 per cent) is the significant level, which is coefficient of variation for the district as well. The blocks possessing below 60 per cent of coefficient of variation are to be considered above significant level. The number of such blocks is thirteen, which lie in the western and southern part of the district. Thus, the twenty blocks of the district are categorised into the following five belts (Table III & Fig. 3) :

(1) Belt of highest degree of development : This belt consisting of Chhaprauli, Baraut, Baghpat and Khekra blocks is situated in the extreme western part of the district Meerut. Lowest dispersion (47.9 per cent) noted here denotes the highest degree of development. Such favourable conditions exist because of fertile soils, more irrigated area and hardworking agricultural population.

(2) Belt of higher degree of development : Large part of this category lies in the south comprising Dhaulana, Hapur and Simbhauli blocks. One block of Binauli is, of course, situated in the north along the Hindon. Dispersion of factors' force (53.9 per cent) is more than that found in the first belt. Fertile irrigated 'bangar' soil stretches in this belt.

8. Macro-Regional Survey of South India, *Indian Statistical Institute* (1962).

9. M.N. Pal, 'Regional Disparities in the Levels of Development in India', paper contributed to the 5th *Indian Econ. Conf.*, Delhi (1965).

10. S.P. Gupta, *Pract. Statistics* (1971), pp. 180-81—formula : $c. v. = \frac{\sigma}{\bar{x}} \cdot 100$
(c. v. = Coeff. of variation, σ = Standard deviation and \bar{x} = mean of the six factors).

TABLE III

Mean, Standard Deviation and Coeff. of Variation for Six Factors

S. No of Blocks	Name of the Blocks	Mean	Standard Deviation	Coeff. of Variation (in %)	Rank
1.	Meerut	19.2	11.5	60.0	13
2.	Jani	11.0	6.4	58.2	10
3.	Rehta	11.5	7.3	63.5	15
4.	Sardhana	23.2	14.3	61.7	14
5.	Binouli	24.0	12.8	53.3	6
6.	Saroorpur	12.9	7.4	57.4	9
7.	Maruana	14.0	9.5	66.4	17
8.	Hastinapur	15.5	12.8	82.6	20
9.	Prikshit & garh	21.0	17.3	82.4	19
10.	Hapur	28.0	14.7	52.5	5
11.	Simbhavli	24.6	13.8	56.5	8
12.	Garh-Mukteswar	15.5	12.3	72.8	18
13.	Dhaulana	23.4	12.5	53.4	7
14.	Loni	16.4	9.6	59.0	11
15.	Bhojpur	16.4	9.7	59.2	12
16.	Murad Nagar	15.7	10.2	65.0	16
17.	Baghpat	21.4	10.9	50.8	4
18.	Khekra	23.7	12.0	50.7	3
19.	Chhaprauli	14.0	57.0	40.7	1
20.	Baraut	17.0	84.0	49.4	2

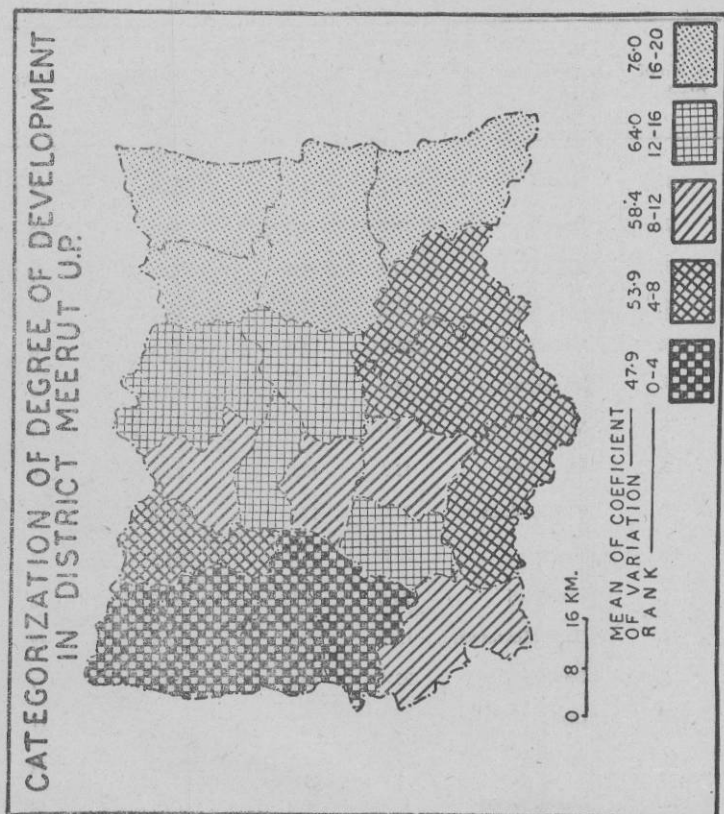


Fig. 3

(3) Belt of high degree of development : It consists of Loni, Jani, Bhojpura and Sarurpur blocks, where dispersion force (58.4 per cent) is below the significant level and thus degree of development is again

above the average. It has resulted apparently due to more of human endeavour in the shape of tubewell irrigation. Fertile upland soils are gifted by nature.

(4) Belt of low degree of development : Another four blocks, namely Muradnagar, Rohta, Meerut and Sardhana are situated in this category. Soils are comparatively less fertile because of frequent occurrence of saline patches. Besides, there is more of urban influence in this part of the district in the shape of non-agricultural uses. Naturally, the dispersion of the factors' force (64 per cent) is above the significant level.

(5) Belt of lower degree of development : The area pertains to a continuous chain of blocks namely Mawana, Hastinapur, Parikshitgarh and Garhmukteshwar girdling the Ganga in the eastern part of the district. Large area of Ganga *khadar* undermines the land utilization in all the seasons of the year. The soils are also not much fertile. Obviously, such conditions have resulted into greater dispersion (76 per cent) of factors' force.

Conclusion

In this paper multivariate correlation analysis has been quantitatively used to study the combined effect of sixteen significant factors of land use belonging to physical, agricultural and population groups in district Meerut of Uttar Pradesh. The coefficient of correlation matrix of product moment proves of much utility in bringing regional contrasts in such land use studies where large number of indices are involved. The purpose of study is aimed at finding inter-correlations among the factors tracing their individual force and analysing critically the factors' dispersion.

Out of sixteen variables six variables of irrigation, gross cultivated area, wheat area, maize area, total block area and water-table contribute (50 per cent) of force. In other words these six factors bring highest influence upon the land use of the district Meerut. Their dispersion is lesser in the western part than in the eastern part of the district. Hence, the degree of development is also higher in the west and the south as compared to the east and middle-north.