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An Optimisation Towards Spatio-Functional Decentralisation and Area Development

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1. Introduction

The failure of 'trickle-down mechanism' of spatial system disturbs 'size-ratchet sequence', evolves duality in space economy and creates problems of rural-to-urban migration. It enhances the rate of economic growth of urban centres and, simultaneously, increases supply of unskilled urban labour at all hierarchical levels. As a result, growth (followed by stagnation) polarises the economic system. The Indian structure of spatio-functional organization has become dysfunctional and system wise weak, with the result that the functional hierarchies (vertical space relations) and their areal patterns (horizontal distribution) follow the law of primacy. Particularly, in the plain areas of North India, the central place system follows the administrative norms (K=7) with low degree of spatial multiplier effects of governmental funds, invested over various plan periods after independence (Singh 1985). Therefore, decentralisation processes of spatio-functional organisation must essentially be considered for formulating district plans.

Decentralisation processes are fundamentally based on distance-location relationship established in spatio-functional organisation. How the tendencies of the average distances of the system change when locations of the functions/fecilities are expanded over space and to what extent this relationship is ideal ? These questions of distance-location relationship determine the aim of the present study. The present research focusses attention upon (i) to prepare a suitable methodology for establishing distance-location relationship, and (ii) to testify its logical significance by considering a spatial unit at micro-level which incorporates an area of about 1000 sq.km. of middle Ganga-Ramganga *doab*.

2. Spatial Efficiency Criteria

The studies on the central place system (Christaller 1933, L$_o$sch 1954), growth pole theory (Perroux 1964), spatial diffusion of information (Hagerstrand 1965) are mainly related to tertiary and secondary activities of inter-regional space economy. We find that Loschean efficiency criterion is fundamentally based on least cost location and/or profit maximisation of services with the condition of least competition (L$\ddot{o}$sch 1954). But the degree of spatial efficiency in developing and underdeveloped economies where local resources are sufficient and exploitable within the spatio-functional organisation, is very low and must be guided by the objective function of trilateral processes of

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location : maximisation of utilisation of resources potentials, minimum access standards in terms of locational selectivity, and decentralisation of complex and aggregated forms of functions/facilities. Such spatial efficiency criteria should be normative and suitable for accelerating the locational decision-making process. They can be described by preparing an analogous structure of spatio-functional organisation. Its functioning can be termed as a 'devised system'.

3. Methodology

The study area, being an agriculturally dominated economy, a total of sixteen agro-economic and socio-administrative functions/facilities have been taken into account for the analysis of existing (1981) as well as devised (for 1991) spatio-functional organisations. Each of the function/facility has been assigned a weight according to its associated resource potential so that proper coordination of resource structure with the spatio-functional organisation can be made (Table 1.1). The choice of locations according to the minimum access standards of each of the function/facility, as the second important aspect of efficiency criterion, has been determined by employing 'Location Allocation Program' which is based on Pythagorean theorem used in Weber's normative model (Cooper 1967, Rushton and others 1973, Goodchild and Noronha 1983, Nichols 1984). This method is applied for optimal partitioning of the sets of locations and their centroids (i.e., source points) and hinterlands for each of the function/facility. Such forms of optimal hinterlands are called Dirichlet Regions by Scott (1971). Further, the solution of their superimposition (meaning the composite picture of the multi-functional optimal hinterlands of the total sixteen functions/facilities) has been prepared by adopting the Boots' model of 'weighting thiessen polygons' (Boots 1980).

The method of optimal partitioning generates data of two normative variables for system's optimality, namely, the location of centroids and average distances between the centroids and locations located within their hinterlands, by which distance-location relationship can be established. This relationship must explain the decentralisation tendencies of spatio-functional organisation and should help to accelerate decision-making processes for the preparation of spatial investment strategy. Before describing logical procedure of this relationship, some of the basic assumptions of the optimisation model are stated as the following :

4. Assumptions

There are three important normative assumptions which have been considered for the present study.

i) All locations(n) remain fixed throughout the assignment when growth processes are operative in the area.

ii) The travel costs are directly proportional to distance, i.e., assumed linear and the consumers/commuters of lower order locations go to their nearest surrounding neighbour centroids(m) and distances between m and n are assumed linear due to plain topography of the area.

iii) The existing distribution of functions/facilities is not optimal because it has dysfunctional and weakened componental relations, while, according to sectoral budget allocations, spatial system requires its further expansion.

On the basis of the above assumptions, there are two noticeable and real conditions of system's optimality. (a) The number of centroids, m, are inversely proportional to the average distance of centroids and locations, $\bar{R}$, and, therefore, distance-location relationship in the system is curvelinear in a concave shape as shown by empirical examples. (b) If the total structural costs of both the components as C for all m and K for total $\bar{R}$ (it means average cost for centroids as $c = C/m$ and average costs per unit of distance as $k = K/\bar{R}$) are assigned and tendency of concavity is recognised as 'Locus of centroids', then cost equilibrium establishes a feasible solution for spatio-functional decentralisation at its tangent point, i.e ,

$$dk\bar{R} = dcm \quad \text{or} \quad d\bar{R}/dm = c/m, \qquad \ldots(1)$$

Note that c and k are constants of distance-location function for which a logical procedure is required.

5. Procedure

Now the question arises, how distance-location relationship is logically established and what would be its real form ? The following steps should be helpful for understanding the reasoning about the feasible solution of the system for existing as well as devised spatio-functional organisation.

Let us first assume that the hypothetical speculation of 'isolated area' is perfectly uniform as Christaller believes, and then ascertain that distance variable is location dependent on spatio-functional organisation of the system. If all services/facilities are to be provided to only one centroid ($m = 1$) in the whole area and thus, total location units, n, are assigned to 1 (case of the complete diversification), then the average travel distance, $\bar{R}$, will be maximum, $\bar{R}_1$. In the reverse case, if all services are to be provided to all locations (case of complete uniformity, $m = n$), then the average travel distance will be minimum as $\bar{R}_1/n = 0$. But both the conditions of decentralisation are not applicable due to unubiquitous nature of services. Processes of functional spread must be accelerated upto a certain but significant locational level of m centroids where average travel distance would be $\bar{R}_1/m$, with the conditions of $1 < m < n$.

The difference between $\bar{R}_1/m$ and $\bar{R}_1/n$ will vary according to the increase or decrease in the number of centroids. In this relationship, $\bar{R}_1$ and $\bar{R}_1/n$ are constants. Thus distance-location function may be defined as :

$$\bar{R}(m) = \bar{R}_1/m - \bar{R}_1/n,$$

or $$\bar{R}(m) = \bar{R}_1(m^{-1} - n^{-1}) \quad \ldots(2)$$

where m are integer values of independent variable, and it varies in its reciprocal form in hypothetical case.

The concavity of real locus may be determined by replacing gradient constant, i.e., unity in hypothetical case, to another constant as α. Thus, real form of locus would be

$$\bar{R}(m) = \bar{R}(m^{-\alpha} - n^{-\alpha}), \quad \ldots(3)$$

where α will always vary negatively as

$$0 < \alpha < 1.00 .$$

If structural variables of costs of the system c and k are introduced in the above equation (3), then the optimised conditions of decentralisation processes may by determined by calculating tangent at a point on cost biased locus, that is

$$k\bar{R} = c\,\bar{R}_1(m^{-\alpha} - n^{-\alpha}). \quad \ldots(4)$$

The point where the first order differentiation of the above equation will be equal to a constant (c/m) which satisfies the equation (1), can be expressed as follows :

$$d\bar{R}/dm = -\alpha R_1(c/k)(m)^{-\alpha - 1} = c/k \quad \ldots(5)$$

By simplifying it for m and $\bar{R}$ values, one can find out the optimal solution of decentralisation processes.

6. Results

For the present study of spatio-functional decentralisation of Amroha tehsil of Moradabad district lying in the middle part of Ganga-Ramganga of the Northern plains of India has been taken into account for testing of the model. This area is agriculturally advanced but having the problems of primacy, diverse and weak spatio-functional organisation, where the central place system is based on 'administrative principle' (K=7) in existing conditions.

Further expansion of spatio-functional organisation means the areal requirements depicted in Table 1.1, have been determined according to the weights assigned to each of the location of the tehsil (n=500), on the basis of their local resource availability,

following the norms of Sixth Plan perspectives for existing (1981) and of the Seventh Plan for devised (1991) systems. The centroids and the average distances of each hinterland have been identified and new optimal locations and functions/facilities have been proposed to form devised spatio-functional organisation in the area. A few but important results have been brought out from the present procedure that can be described in the following manner.

Table 1.1 Process of Locational Expantion and Weight Assignment

Name of Services/ Facilities	No. of Existing locations having services (1981) (Ws**)	Proposed No. of locations having Services* (1991) (Ws**)	Locational Expantion	
			Total No.	%
(A) **Educational :**				
1. JBS	246(W1)	483(W2)	237	96
2. SBS	20(W1)	48(W2)	28	140
3. HSS	4(W1)	30(W2)	26	650
(B) **Medical :**				
4. PHC and H	8(W1)	8(W2)	—	—
5. Disp., FP and MCW	27(W1)	64(W2)	37	137
(C) **Postal :**				
6. PO	16(W1)	24(W2)	8	50
(D) **Market :**				
7. 'Hat'	14(W3)	20(W3, W4)	6	43
(E) **Banking :**				
8. Bank	5(W5)	10(W5)	5	100
(F) **Agro-based Services :**				
9. Ag. Ext. and Storage	13(W5)	25(W5, W6, W7)	12	92
10. Cane-Crushing	20(W3)	40(W3, W4)	20	100
(G) **Administrative :**				
11. Block Hqs.	3(—)	3(W2)	—	—
12. N. Punchayats	27(—)	27(W2)	—	—
Total Central Place System	50 K=7	64 K=4		

* Proposed number of total locations for each service have been determined according to 7th Plan norms suggested by Planning Commission, New Delhi.

** Resource-potential Weightages (Ws) alloted to given services as shown in brakets. Their names are : W1=Total Population 1981 ; W2=Proposed Population 1991 ; W3=Total Unemployment 1981 ; W4=Total Surplus Production (in thousand qtls.) 1981 ; W5=Magnitude of total agr. Potentiality w.r.t. Technological Inputs 1981 ; W6=Capacity of Ag. Intensity (in%) 1981, Calculated as : (G.C.A/NCA) x 100 area of Double Cropped ; W7=Reciprocal rate of Inputs'-Substitution 1981, i.e., marginality of technology in proportion to labour marginality in its reciprocal form as : $((\delta X_1/\delta X_2)^{-1})$.

(I) Table 1.2 depicts the nature of the distribution of existing as well as optimal functions/facilities and their accessibilities. It concludes that there seems to be a significant distance reduction tendency of the functions/facilities ranging from 7 per cent for administrative services to 69 per cent for the lowest level educational facilities. On the whole, when we compare existing system with the devised one, it is obvious that an average distance reduction within the whole system is 37 per cent from 7.1 Km to 4.5 Km., when fourteen newly proposed rural growth locations are to be added in the existing system (Table 1.2). The distributional patterns of the functions/facilities are basically clustered and random in the existing set-up and would be uniform if the devised system is proposed to be implemented.

(II) The priorities of the functions/facilities may be determined on the basis of average distance reduction. Higher percentage of the reduction of average distance of function/facility indicates its urgent need in the area with higher priority and *vice-versa*. Educational facilities, particularly, Junior Basic Schools and Higher Secondary Schools that have higher distance reduction in decentralisation processes, 69 per cent and 54 per cent respectively, must be put on first priority in Amroha area, although their distributional patterns are more or less unifrom. Canecrushing centres, the back-bone of the economy of area, are also required for further expansion on proposed locations. It stands as a second priority due to its high reduction rate of average distance (50%) for transporting raw sugarcane from fields to crushing centres when sugarcane crushing centres are enhanced according to given decentralisation norms. Medical services, specially dispensaries and family planning centres must be given as a third priority level (Table 1.2).

(III) The curvelinear tendencies of distance-location relationship have been computed by calculating the values by equation (4) for existing, devised and hypothetical patterns of the system. The following are the numerical forms :

1. for existing locus (1981),
$$\bar{R}(m) = 25.0 \left(m^{-.3993} - n^{-.3992} \right),$$
2. for devised patterns (1991),
$$\bar{R}(m) = 25.0 \left(m^{-.5701} - n^{-.5701} \right), \text{ and}$$
3 for hypothetical patterns,
$$\bar{R}(m) = 25.0 \left(m^{-1.00} - n^{-1.00} \right).$$

Where $n = 500$.

Table 1.3 and Figure 1 which depict their patterns, indicate that the locus of the devised patterns is nearer to hypothetical conditions than existing ones. The general slope of this locus, i.e., the indicator of marginal decreasing rates of average distance is

Table 12 Distributional Patterns and Changes in Functional Accessibility in Amroha Tehsil

(Distance in Km)

Name of Services Facilities	Existing conditions (1981)		Optimal solution (1991)		Distance Minimisation	
	Patterns (Rn)	Average Distance	Patterns (Rn)	Average Distance	Total	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. **Educational :**						
1. JBS	1.6371*	1.9	2.0031*	0.6	1.3	69
2. SBS	1.1886+	5.3	1.9943*	3.9	1.4	26
3. HSS	0.7616£	16.0	1.9428*	7.4	8.6	54
B. **Medical :**						
4. PHC and H	0.3464£	11.2	1.9428*	7.4	3.8	34
5. Disp., FP and MCW	0.5627£	4.0	1.7893*	2.0	2.0	50
C. **Postal :**						
6. PO	1.6153*	4.1	1.7130*	3.0	1.1	26
D. **Market :**						
7. 'Hat'	1.0653+	6.3	1.3682*	3.9	2.4	37
E. **Banking :**						
8. Bank	1.2205+	7.9	1.2842*	5.3	2.6	33
F. **Agro-based :**						
9. Ag. Ext. and Storage	1.3906+	5.2	1.6243*	3.3	1.8	35
10. Cane-Crushing	1.2132+	4.4	1.5731+	2.2	2.2	50
G. **Administrative**						
11. Block Hqs.	1.1718+	13.2	1.7951*	12.3	0.9	7
12. N. Panchayats	1.3464+	4.3	1.6244*	3.3	0.9	22
Central Place System	0.8706£	7.1	1.4556	4.5	2.6	37

N.B. : (1) Col. (7)=[Col. (3)−col. (5)=Col. (6)]/Col. (3) and the results are converted into per cent by multiplying it into 100.

(2) Column (2) and (4) denote distributional patterns, that have been concieved on Nearest Neighbour Analysis (Rn). Rn ranges from zero for perfectly clustered, through one for Randomness, to a maximum of 2.15 for perfactly uniform. In present case, £, + and * denote Clustered, Random and Uniform patterns of service distribution respectively.

steeper at about 65° in later stages of decentralisation processes in Amroha tehsil. The two are the fundamental causes of downward locus deviations ; (a) undulating resource-potential surfaces (as system's weights), and (b) gradual changes in distributional patterns of location selectivity and functional complexity (from clustered and random to uniform patterns).

(IV) Introducing cost variables in the devised locus (as equation 3) including construction (Non-Recurring expenditure) and maintenance (Recurring expenditure) costs of the function according to a study on sectoral unit cost (1981), it is interesting to note that the optimal point (i.e., the tangent point as 'e' on existing and 'd' on devised conditions (see Figure) are shifting downward (Table 1.4).

Table 1.3 Observed and Calculated Average Travel Distances ($\bar{R}_o$ and $\bar{R}_c$) in the Loci of Existing (1981), Devised (1991) and Hypothetical Patterns of Spatio-Functional Organisation in Amroha Tehsil

($\bar{R}$ in Km)

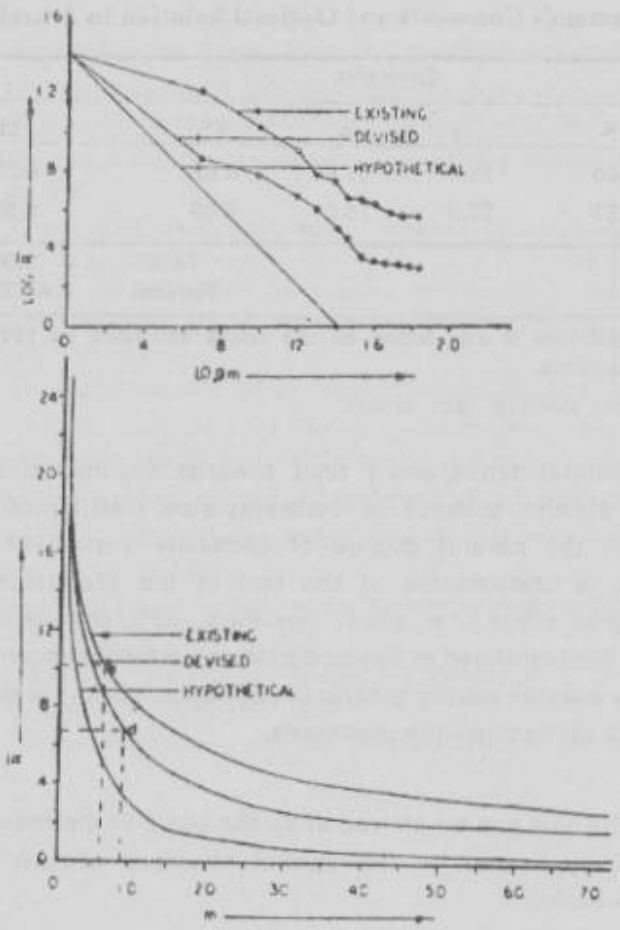
No. of Centroids, m	Existing		Devised		Hypothetical
	$\bar{R}_o$	$\bar{R}_c$ (α=0.399)	$\bar{R}_o$	$\bar{R}_c$ (α=0.570)	$\bar{R}_c$ (α=1.000)
1	19.00	25.00*	25.00	25.00*	25.00*
5	11.13	11.08	10.02	9.37	4.95
10	8.08	8.02	6.00	6.00	2.45
15	6.53	6 43	4.63	4.62	1.62
20	5.72	5.49	3.81	3.81	1.20
25	4.81	4.77	3.03	3.30	0.95
30	4.29	4.31	2.73	2.82	0.78
35	4·08	3.91	2.40	2.33	0.66
40	3.83	3.60	2.00	2.28	0.57
45	3.66	3.42	1.95	2.19	0.51
50	3.54	3.22	1.80	2.15	0.45
55	3.48	3.00	1.78	2.00	0.41
60	3.37	2.82	1.77	1.95	0.37
65	3.29	2.75	1.75	1.91	0.32

N. B. : 1. The values $\bar{R}_c$ are calculated putting various α values in the long-normal form of locus

$$\bar{R}_e = \bar{R}_1 (m^{-\alpha} - n^{-\alpha}).$$

2. Distributions of $\bar{R}_c$ are significant at 5% levels in existing as well as in devised patterns.

* Although, $\bar{R}_1$ varies according to α because of insertion of reduction-constant, n $^{\alpha}$, in the above referred hyperbolic form and, therefore, i.e., calculated 22.93 Km. in existing, 24.39 Km in devised and 24.95 Km in hypothetical patterns, however, it is fixed as $\bar{R}_1$ = 25.00 for all the cases.



The solution as given in Table 1.4 brings out evidence of gradual shift in the system-integration towards more realistic forms and, hence, an optimal change in the number of locational centroids, m, from 6 to 9 is observed. Thus, a half time increase of new functions and functional intensities at new locations would reduce an average travel distance to 3.6 Km., from 10.0 Km. in the existing to 6 3 Km. in devised patterns. The percentage of cost reduction on an average distance is lesser (36 5%) than the increasing budgetary provisions on functional structure (47.7%) ; however, this cost distance reduction would affect long term locational policies to produce greater comfort to the rural-masses in their travel costs.

(V) Applying 'rank-size rule' of Zipf (1949) with the consideration of functional aggregation of the centres as size of the locations in spatial system, the change in spatial multiplier effect can be gauged. Whereas changes in 'rank-centrality size' regularities

Table 1 4 System's Constants and Optimal Solution in Amroha Tehsil

Systems	Constants				Solution	
	α	$\bar{R}_1$	c*	k*	m	$\bar{R}$
Existing (1981)	.40	25.0	11.58	8.82	6.291	9.931
Devised (1991)	.57	25.0	16.01	6.89	9.292	6.304
Changes in Optimality				Total	+ 3.001	-3.627
				Per cent	47.704	36.523

N. B. : Solution for devised patterns is also based on the prices estimated for 1981. This is changeable subject to price-fluctuations.

*C and k are average costs in lakh rupees.

(as 'q' value of log-normal tendencies) tend towards log-normal optimality from a steeper concavity or greater primacy in centrality-size distribution (when $q = 1.80$ in existing conditions), to the normal degree of concavity ($q = 1.224$) in the devised distribution. There is, a confirmation of the fact of the gradual improvement in the degree of spatial multiplier effect (i.e., about one-third, 32% change in overall system vertically) Thus, the decentralised or devised patterns are consequently more capable of acting in an effective manner having greater impact upon socio-economic development by putting a slight check on immigration processes.

7. Conclusion

The following conclusions can be arrived at on the basis of the results of the present study which is especially related to the spatial structure of such an area where the entire economy is agro-based.

(1) Functions/facilities will follow uniform distributional patterns rather than cluster or random ones when the normative location plan is implemented.

(2) There must be gradual improvement in the degree of spatial efficiency, that has been gauged by calculating the parameter of rank-centrality relationship of spatio-functional organisation, if the expansion norms of the functions/facilities are followed rigorously ; and

(3) If a few functions/facilities which are directly related to the agricultural activities (or areal economy) and human skill the educational and medical facilities, are to be provided on specified proposed locations of spatio-functional organisation, then it will help to reduce a third of travel costs for rural commuters who go to the nearest centres for getting these facilities.

Preconditions of the model can further be relaxed and it can be tested for area development of the other parts of the country.

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