TRANSPORT DEVELOPMENT IN NORTHWESTERN INDIA — A CASE STUDY OF DELHI-JAIPUR-AGRA TRIANGLE

By

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It is certified that the dissertation entitled 'Transport Development in North-Western India - A Case Study of Delhi-Jaipur-Agra Triangle' submitted by Shri Rocket Ibrahim in fulfilment of six credits out of total requirements of twenty-four credits for the degree of Master of Philosophy (M.Phil) of the University, is his original work according to the best of our knowledge, and may be placed before the examiners for evaluation.

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(Rocket Ibrahim)

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C O N T E N T S

CHAPTER I

REGIONAL PROFILE

I. Role of Transport in the Economic Development

Transport is a necessary condition for the economic development of a country. The success of different sectors of economic development, which depends on their level of mobility and accessibility, is determined by the degree of transport development. Transport has considerably narrowed down the gap between producers and consumers and extended the areal limits of regions/centres specialising in agriculture and industry or any other activity. While on the one hand, transport mobilizes the economy of the regions, brings them in closer economic web, on the other hand, the volume of transport depends upon the degree of economic development in a region.[1] Higher the development greater would be the volume of transport. The system of transport anyhow forms the base for the exploitation of natural resources, importing the technical knowhow, import and export of raw material, finished products, capital, skilled/unskilled labour and the entrepreneurial skill which in turn boosts the economic development of the region. Hence lies the importance of the study of transport system in a region.

Transport is the single important factor on which hinges the entire industrial activity of the country.[2] It has played an important role in supplying raw materials to industry and in moving finished products to market. To operate efficiently,

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1. Owen, Wilfred (1964): Strategy For Mobility, Brookings Institution, Washington, p.19.

2. HMT (1968): Road Transport Development in India, Calcutta, p.3.

factories need continuing supplies of fuel, raw materials, and spare parts and an easy and quick accessibility to the market where they can sell their produce. Sometime a factory may be able to utilize only a part of the installed capacity or other inputs in time because of the transport constraints.

Just like industry, agricultural efficiency also suffers[3] because of the inadequate provision of roads and road transport in rural areas. Inputs like commercial fertilizers may arrive after the growing season is half over or not arrive at all because of inadequate provision of goods transport facilities. The high cost of moving farm products and the long delays and consequent damage and loss to perishable commodities have their repercussions on food supplies. When the farmers find that what they grow cannot be moved easily and cheaply to profitable markets, they have no incentives to grow surpluses.

In Thailand, the Friendship Highway, completed only a few years ago,[4] has transformed partially used jungle-land along its hundred mile route into high productive and prosperous farms. Within three years after the construction of highway, the production of sugarcane, vegetables, bananas, and other fruits more than tripled in tonnage. In Bolivia, the highway from Cochaleamba to Santa Cruz reduced travel time in rainy season from several weeks to fifteen hours and provided a link between

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3. Owen, Wilfred (1968): Distance and Development: Transport and Communications in India; Brookings Institution, Washington; p. 56.

4. Op.Cit., p.7.

the country's food supplies and its people. Until then the price of home grown rice was 50 per cent higher than imported rice because of the high cost of the transport.

The greater mobility provided by transport investments has also played an important part in extending the benefits of education, in communicating new ideas, and in overcoming the isolation.

The transport has become not only the artery and vein of the modern industrial economy but also the main assurance of national security.

II. Selection of the Region and Research Design:

This study deals with the transport development in North-West India, a case study of Delhi-Jaipur-Agra Triangle (map no.1). This triangle is formed by national highways No.8, 9, 11 in which Delhi forms the apex in the North and Jaipur (West) and Agra (East), the two angles of the base line. The area between Delhi, Jaipur and Agra national highways triangle possesses a complete system of road network. In addition to the national highways, there are a number of subsidiary roads within this region which bring the settlements of the region in contact with the national highways and in turn link them with the national network system. Thus the national highways serve as the outlets for the region.

In this study, the transport development of Delhi-Agra-Jaipur triangle has been studied in the context of road network


DELHI-JAIPUR-AGRA
TRIANGLE
ADMINISTRATIVE DIVISION
20 0 20 miles
DELHI
GURGAON
BALLAB-
GARH
REWARI
NUH
PALWAL
BEHROR
MANDAWAR
TIJARA
F-JHIRKA
KISHAN-
GARH
BANSUR
KOTPU-
TLI
KAMAN
CHHATA
ALWAR
NAGAR
DEEG
MATHURA
THANA-
GHAZI
BAIRATH
LACHHMAN-
GARH
BHARAT-
PUR
RAJGARH
NADBAI
AGRA
AMBER
JAMWA-
RAMGARH
KIRAOLI
MAH-
WA
WEIR
BASWA
JAIPUR
DAUSA
SIKRAI
TODA
BHIM
BASSI
INDIA

FIG·1

development and bus connections. The study thus has been divided in three parts. In the first part an index of road network efficiency has been prepared and road network development has been analysed. In the second part, the bus connectivity has been studied in terms of direct connections of settlements by the bus within the Tehsil and outside the tehsil. In the third part, the inter-relationship between the road network development and connectivity by bus has been analysed.

III. Region and its setting:

In this section a brief background to different environmental characteristics of the region like physiography, natural vegetation, climate and demographic characteristics have been highlighted to enable us to have a reasonable background of the region to understand the causes and correlates of network system.

(i) Physiography:

The Aravalli hills cover considerable area of the region. This extends from north to south in the western part of the region. This uninterrupted chain of hills intersects the Alwar district into two parts. The part lying to the west of these hills is a level plain more or less sandy and dotted with isolated small hills; while on its eastern side there is a succession of hill ranges lying north and south, parallel to each other. The north and some portion of the West of the district have shifting sand dunes. In Jaipur district also we

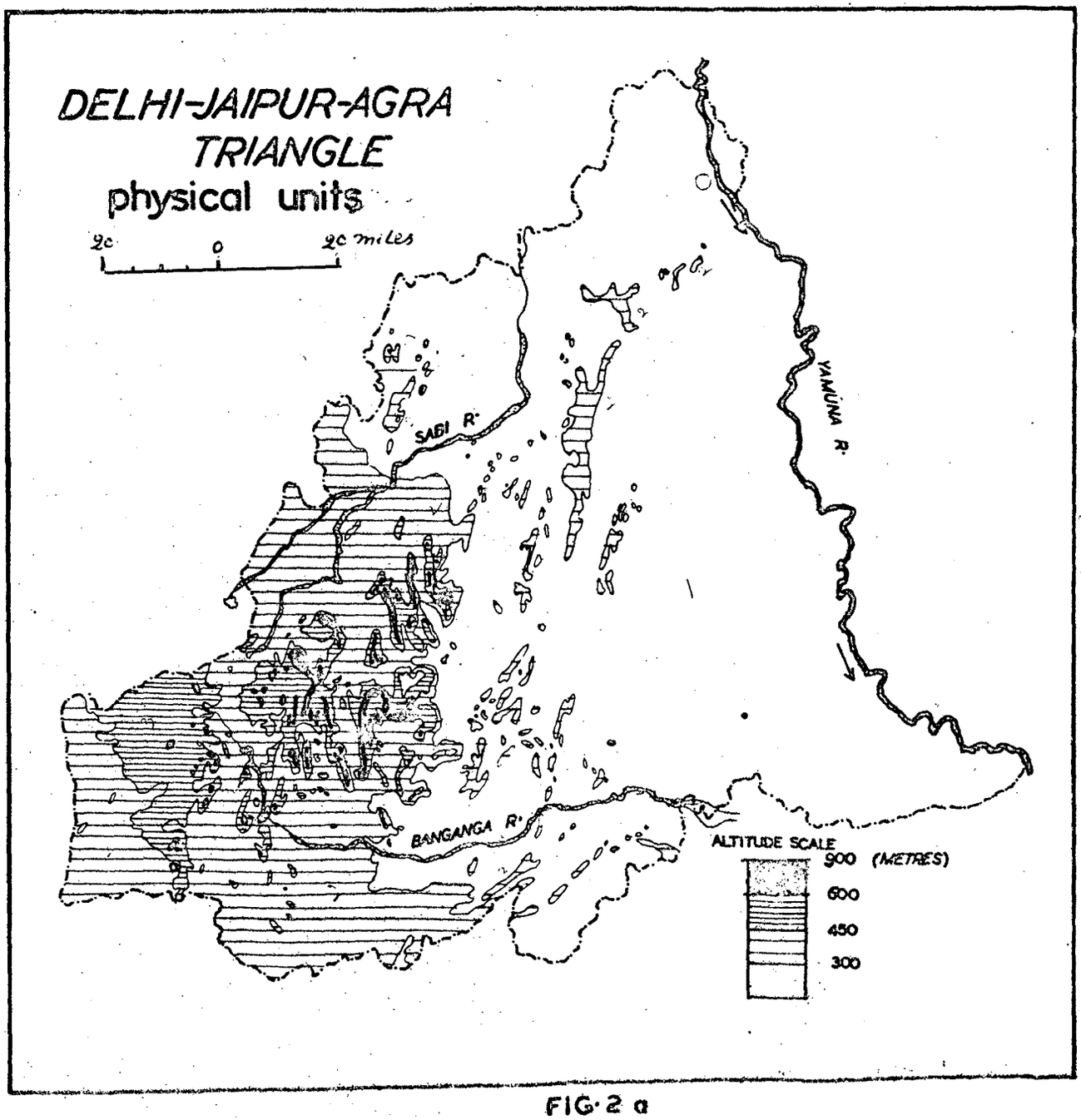
DELHI-JAIPUR-AGRA
TRIANGLE
physical units
20 0 20 miles
SABI R.
YAMUNA R.
BANGANGA R.
ALTITUDE SCALE
900 (METRES)
600
450
300

FIG. 2 a

find the vast quantities of sand which is sometimes imported to some other districts. ~~Most part of Bharatpur district is level and terrain.~~ These are several ranges of hills belonging to the Aravalli system. The overall picture of Bharatpur district is that of an alluvial plane with detached bare hills in the north and fairly well wooded hills in the south. The tehsils of Kirauli and Agra are practically a level stretch of loamy soil, broken only by Khari river. A few outcrops occur rising out of alluvial plains in/~~e~~South, from Fatehpur Sikri to Kiraoli. In Gurgaon also there are low hills extending north to south which are the extensions of Aravalli ranges. Southern part of Delhi has somewhat rugged surface where altitude exceeds sometimes more than 300 metres. In thewhole region the area between Alwar, Bansur, Bandikui and Jamwa Ramgarh is well wooded leaving aside some desert part of the region in south and southwest. Most of the remaining area is a levelled fertile and alluvial plain. Only the tehsils in south western part of the region, i.e., Kotputli, Bairath, Amber, Jaipur, Bassi, Jamwa Ramgarh, Dausa, Thanagazi, Western part of Alwar tehsil, Bansur and Mandawar have comparatively high altitude ranging from 300 to 600 metres. These tehsils have rugged surface. Rest of the tehsils of the region, with the exception of few patches of higher altitude have altitudinal range from 150 to 300 metres. The tehsils of higher altitude are intersected by Sabi and Banganga rivers and their tributaries and other smaller rivers. Yamuna river is making eastern boundary of the region. The region has many lakes also which are generally used for agricultural purposes.

(ii) Drainage System:

There is no river in the region which is perennial in its entire course except Yamuna which only touches the north-eastern border of the region. Most of the rivers of the region rise from Aravalli Hills (ranging in altitude from 300 to 600 metres). Several of the rivers and their tributaries which carry the drainage of the hills have been impounded at suitable sites, the water of which is used for irrigation purpose. Many of the rivers are useful because of their floods which enables that area for sowing. The silt of some of these streams is highly fertile and crops are grown in the river beds after the rainy season. Some of the rivers are also the main source of drinking water.

On the whole, drainage lines are few in the region. But the Aravalli range which runs roughly from north to south gives rise to a number of drainage lines. Therefore, the area along this hilly track has good network of drainage, though most of the rivers which rise from here are dried up within a few months.

Ruparel and Sabi are the important rivers of the region. Chuher Sidh, Landoha, Banganga and Khari Nadi are other smaller rivers of the region.

(iii) Natural Vegetation:

Forests do not cover a large part of the region. They are confined to the Aravalli Hills. The percentage of area covered under forest in Alwar district is highest (2.7%). The forests

found along the Aravalli hills are generally of dry deciduous and scrub type. Whatever small proportion of Delhi area which comes under forests is covered by Babul only. Seventeen per cent of the area of Bharatpur which comes under forest is also covered mainly by dry deciduous type of forests. The timber obtained from the forests of this region is utilized for the manufacture of agricultural implements for roofing as well as for field purposes.

(iv) Climate:

The region has got a semi-arid type of climate. The whole of the region cannot enjoy the full benefits of the monsoon season. The depressions exhaust their moisture by the time they reach this region. The climate is characterised by excessive dryness and hot summer and cold winter. Most of the rain comes in the month of July, August and September. The rainfall is unreliable. The average annual rainfall range from a minimum of 46.71 Cms (Delhi) to a maximum of 69.57 cms (Alwar). The tehsils of high rainfall are located in the east and southeast of the region (see table I). Most of the tehsils in the west of Aravallis received low rainfall.

In the northern part of the region at Delhi and Gurgaon the variations in minimum and maximum temperature in summer is 10° C (minimum 11° C.) In winter, this range is highest at Delhi - 25° c minimum and 36° c maximum.

Table No. 1

Average Annual Rainfall

S.No.	Tehsil	Rainfall	S.No.	Tehsil	Rainfall
1.	Behror	N.A.	20.	J. Ramgarh	51.66
2.	Mandawar	54.48	21.	Baswa	60.81
3.	Kishangarh	57.73	22.	Bassi	N.A.
4.	Tijara	57.23	23.	Dausa	54.41
5.	Bansur	N.A.	24.	Sikari	N.A.
6.	Alwar	69.57	25.	Malhwa	56.44
7.	Thanagazi	N.A.	26.	Toda Bhim	55.12
8.	Rajgarh	N.A.	27.	Delhi	46.71
9.	Lachhmangarh	53.82	28.	Rewari	65.08
10.	Kaman	64.39	29.	Ballabgarh	63.2
11.	Nagar	58.62	30.	Palwal	61.4
12.	Deeg	68.76	31.	Nuh	60.04
13.	Nadbai	62.64	32.	F. Jhirka	58.09
14.	Bharatpur	66.98	33.	Mathura	66.00
15.	Weir	66.90	34.	Chhata	66.00
16.	Kotputli	49.83	35.	Agra	66.00
17.	Bairath	54.05	36.	Kirauli	66.00
18.	Amber	58.32	37.	Gurgaon	66.05
19.	Jaipur	61.01			

Table No. 2

Average Temperature Winter/Summer

(in C°)

S.No.	District	Winter			Summer		
		Minimum	Maximum	Range	Minimum	Maximum	Range
1.	Gurgaon	11	21	10	20.0	36.0	10.0
2.	Alwar	11.5	15.0	2.5	30.0	32.5	2.5
3.	Jaipur	15.0	17.5	2.5	30.0	32.5	2.5
4.	S.Madhopur	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
5.	Bharatpur	12.5	15.0	2.5	30.0	32.5	2.5
6.	Delhi	11.0	21.0	10.0	25.0	36.0	11.0
7.	Agra	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
8.	Mathura	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

(v) Demography:

(a) Population:

The region is inhabited by 11.8 million persons, out of which 5.8 million are living in urban areas. The region has 48.94 per cent urban population whereas India's urban population is 19.19 per cent. The percentage of urban population in the region is much more than the country as a whole. It is because the region is very small but includes very large urban centres. The region had 37 towns in 26 tehsils. The table No.3 shows the percentage of urban population in different tehsils based on 1971 Census. Out of 37 tehsils only 26 have urban population. Most of thetehsils which do not have urban population are located on the west and southwestern part of the region (west of the Aravallis over a hilly area.) . Tehsils of Alwar district which are purely rural make almost a contiguous region.

(b) Sex Ratio:

1961 Census indicates that the average sex ratio for theentire region was 843 females per thousand male, the rural sex ratio was 878 females per thousand male and for urban population it was 803 females per thousand male. But within the region we find significant variations in sex ratio. For example, Rewari had the highest ratio (926) and Mathura lowest (831) in rural population. While considering urban population, Amber had the highest ratio (901) and Lachhmangarh the lowest (733).

Table No. 3

Demographic Features 1961

S.No.	Name of Tehsil	Dependency Ratio	Sex Ratio		Literacy Rate	Occupational Structure			Appendage 1971	
			R	U		%age of workers in Primary Sector	%age of workers in Secondary Sector	%age of workers in Tertiary Sector	Total Population	%age of urban population
1	2	3	4	5	6	7	8	9	10	11
1	Chhata	1.17	.84	.85	14.7	80.60	6.89	12.51	257905	7.41
2.	Mathura	2.16	.83	.82	28.02	46.13	13.46	40.45	453698	39.49
3.	Kirauli	2.22	.85	.89	16.35	72.71	9.74	17.34	224547	11.47
4.	Agra	2.55	.83	.82	29.40	17.30	30.05	52.65	832312	75.57
5.	Rewari	1.89	.92	.90	23.90	68.51	13.09	18.40	385064	14.98
6.	Gurgaon	1.91	.87	.87	26.11	62.39	12.61	25.00	296149	22.26
7.	Ballabgarh	1.46	.83	.83	27.92	59.24	22.15	18.73	323376	37.98
8.	Palwal	1.50	.84	.89	18.13	71.67	11.05	17.26	284387	17.71
9.	Nuh	1.18	.87	.86	11.72	82.57	7.24	10.18	230663	2.05
10.	F. Jhirka	1.14	.91	.89	9.34	81.72	7.76	10.52	187730	4.24
11.	Behror	1.64	.93	-	18.58	82.44	6.23	11.32	159437	-
12.	Mandawar	1.08	.89	-	15.55	87.02	4.58	8.40	106649	-
13-	Kishangarh	1.57	.87	-	16.85	84.57	4.63	10.80	137365	7.78

1	2	3	4	5	6	7	8	9	10	11
14.	Tijara	1.13	.88	-	11.61	89.27	3.61	7.12	102510	-
15.	Bansur	1.48	.86	-	10.73	84.11	6.06	9.06	97876	-
16.	Alwar	1.15	.89	.86	20.75	72.52	10.80	16.69	312558	32.11
17.	Thanagazi	1.00	.90	-	10.13	78.34	10.81	10.79	87446	-
18.	Rajgarh	1.15	.90	.88	12.39	83.52	7.24	9.24	154186	7.15
19.	Lachhmangarh	1.10	.88	.73	12.07	90.51	3.81	5.68	233135	2.06
20.	Kaman	.98	.88	.86	10.27	98.14	3.64	7.16	148161	10.63
21.	Nagar	.98	.89	.-	11.45	91.12	2.45	6.43	97442	-
22.	Deeg	1.68	.86	.86	15.0	80.85	7.77	14.39	103957	21.42
23.	Nadbai	1.19	.86	.86	17.74	88.69	4.03	7.28	90390	9.72
24.	Bharatpur	1.67	.87	.79	22.27	12.25	8.21	19.01	256008	27.30
25.	Weir	1.10	.86	.86	15.10	87.80	4.88	7.32	117060	7.56
26.	Mahwa	1.08	.89	-	13.80	85.95	6.55	7.50	96828	-
27.	Toda Bhim	.84	.87	.89	13.65	90.11	4.75	5.10	106792	9.79
28.	Kotputli	2.02	.89	.89	12.52	71.83	9.52	18.65	147887	8.35

1	2	3	4	5	6	7	8	9	10	11
29.	Bairath	.96	.93	.87	11.95	71.16	18.40	10.43	157047	-
30.	Amber	1.01	.91	.90	13.25	72.10	16.06	11.85	211014	14.00
31.	Jaipur	2.19	.87	.85	39.15	14.37	29.95	55.69	667937	92.11
32.	J. Ramgarh	.72	.89	-	8.94	77.39	14.34	8.26	156256	-
33.	Baswa	1.02	.89	.84	14.80	80.33	5.58	14.04	131629	5.95
34.	Bassi	.78	.90	-	10.60	82.69	9.67	7.64	102555	-
35.	Dausa	.88	.89	.87	11.67	77.63	13.48	8.89	144405	13.11
36.	Sikrai	.88	.87	-	10.89	85.79	6.35	7.89	93543	-
37.	Delhi	2.11	.84	.78	52.74	8.36	26.02	65.61	4065698	89.70

(c) Occupation Structure:

According to 1961 Census, out of total population of 11762940 persons, 2388932 were enumerated as workers in the whole region, which constitutes 20.30 per cent of the total population.

The primary sector accounted for 66.43 per cent of the labour force, the share of secondary and tertiary sector was 12.39 per cent and 21.25 per cent respectively. Here in this region the proportion of labour force in primary sector was not surprisingly high. It is because the region includes three big cities, one of which is Delhi itself, where secondary and tertiary activities dominate. Nagar has the highest percentage of workers in primary sector (91.12). Primary sector is the weakest in Delhi where only 8.36 per cent of the workers are engaged in this activity. The other tehsils of low primary activity are Jaipur, Agra and Bharatpur. The secondary sector is strongest in Agra, Jaipur and Delhi (with 30.05%, 29.95% and 26.03% labour force respectively).

IV. Levels of Economic Development of the Region:

The analysis of economic development is based on the studies carried out by M.N. Pal and Asok Mitra on the subject. Asok Mitra* has taken 33 variables which have been put under the following five blocks (based on 1960-61 data):

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* Census of India (1961): Levels of Regional Development in India, Part I-A (i) , pp.9-14.

1. Agricultural Infrastructure:

(i) Area under double crop per cent of net area sown.

(ii) Gross area irrigated per cent of gross area sown.

(iii) Households cultivating 0-5 acres per cent of all cultivating households.

(iv) Pure tenancy holdings per cent of all cultivating households.

(v) Hired attached workers per cent of all workers atcultivation.

(vi) Cultivators and agricultural labourers per 100 acres of net area sown.

(vii) Cultivators and agricultural labourers per cent of rural working population.

2. Participation Rates in Traditional Sector:

(i) Male participation rate 1961.

(ii) Female participation rate 1961.

(iii) Males working in agriculture % of male working population 1961.

(iv) Single and family workers in non-agricultural per cent of total non-agricultural workers 1961.

(v) Workers in household industry per cent of total working population 1961.

3. Potential of Human Resources:

(i) Persons per square mile

(ii) Females per 100 males

(iii) Rural population per 1000 of total population

(iv) Percentage increase of population, 1951-61

(v) Immigrants per cent of total population, 1961

(vi) Children 0-4 per cent of women aged 15-44, 1961

(vii) Crude literacy rate, 1961

(viii) Scheduled Tribe population per cent of total population 1961

(ix) Scheduled caste population per cent of total population 1961

4. Distributive Trade, Manufacturing and Infrastructure:

(i) Workers in retail trade per 1000 of total population

(ii) Workers in manufacturing per 1000 of total population

(iii) Census houses used as business houses or offices per 1000 of all census houses

(iv) Census houses used as community centres for 1000 of all census houses

(v) Census houses used as restaurants and eating houses per 1000 of all census houses

(vi) Census houses used as rest houses per 1000 of all census houses

(vii) Census houses used as school houses per 1000 of all census houses

(viii) Census houses used as medical institutions per 1000 of all census houses

(ix) Miles of surfaced roads per 1000 sq. miles of area

5. Organised Industrial Activity in the Modern Sector:

(i) Establishments run on electricity per cent of all industrial establishments

(ii) Workers in registered factories per cent of all workers

(iii) Whether headquarters town (a) generates own electricity or (b) is connected to grid or (c) both or (NE) none.

Asok Mitra has arrived at the composite index by ranking the values of each indicator for all the districts. Based on the above mentioned variables, the districts of Delhi-Agra-Jaipur region have the following values and positions in different levels of development:

S.No.	Name of the District	Position in the levels of development
1.	Delhi	Fourth or top level (Fourth QL)
2.	Gurgaon	-do-
3.	Mathura	-do-
4.	Bharatpur	-do-
5.	Agra	-do-
6.	Jaipur	-do-
7.	Alwar	Third level (Third QL)
8.	S. Madhopur	Second level (Second QL)

However, according to M.N. Pal* who has taken seventeen variables in following four specific groups, there are wide variations in the levels of development of these districts:

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* Pal M.N., "Regional Disparities in the Levels of Development in India", Journal of Regional Science. Fifth Econometric Conference (1965)

Agriculture:

i. Agricultural labour productivity in rupees per person

ii. Agricultural income per acre of cropped area in rupees

iii. Percentage of irrigated area to total gross area sown

Secondary Activities:

i. Percentage share of income in mining, manufacturing and small enterprises

ii. Concentration of labour engaged in secondary activities in number per square mile

iii. Percentage share of labour force in secondary activities

iv. Concentration of large factories (more than 50 labourers using power or more than 100 labourers without using power) in number per thousand square miles.

v. Concentration of all factories in number per thousand square miles.

vi. Concentration of factory workers in number per thousand square miles

vii. Factory workers in per cent of total labourers engaged in secondary activities.

Tertiary Activities:

i. Percentage share of income in commerce, transport, communication and other services

ii. Concentration of labour engaged in tertiary activities in number per square mile

iii. Percentage share of labour force in tertiary activities

Urbanisation:

i. Percentage of total population in urban areas

ii. Average size of a town in thousand person

iii. Concentration of urban population per square mile of total area

iv. Concentration of city population (each city has a population of 5000 persons or more) per square mile of total area

The weights of these variables were determined by the method of principle component analysis. The values in the composite index thus obtained are given in the following table along with their composite level of development.

S.No.	Name of the District	Composite Index values	Levels of Development
1.	Delhi	3.8575	Exceptionally High
2.	Agra	1.6949	Very High
3.	Mathura	1.2825	High
4.	Jaipur	1.1655	High
5.	Gurgaon	1.0848	Medium
6.	S. Madhopur	.8121	Low
7.	Alwar	.8076	Low
8.	Bharatpur	.8052	Low

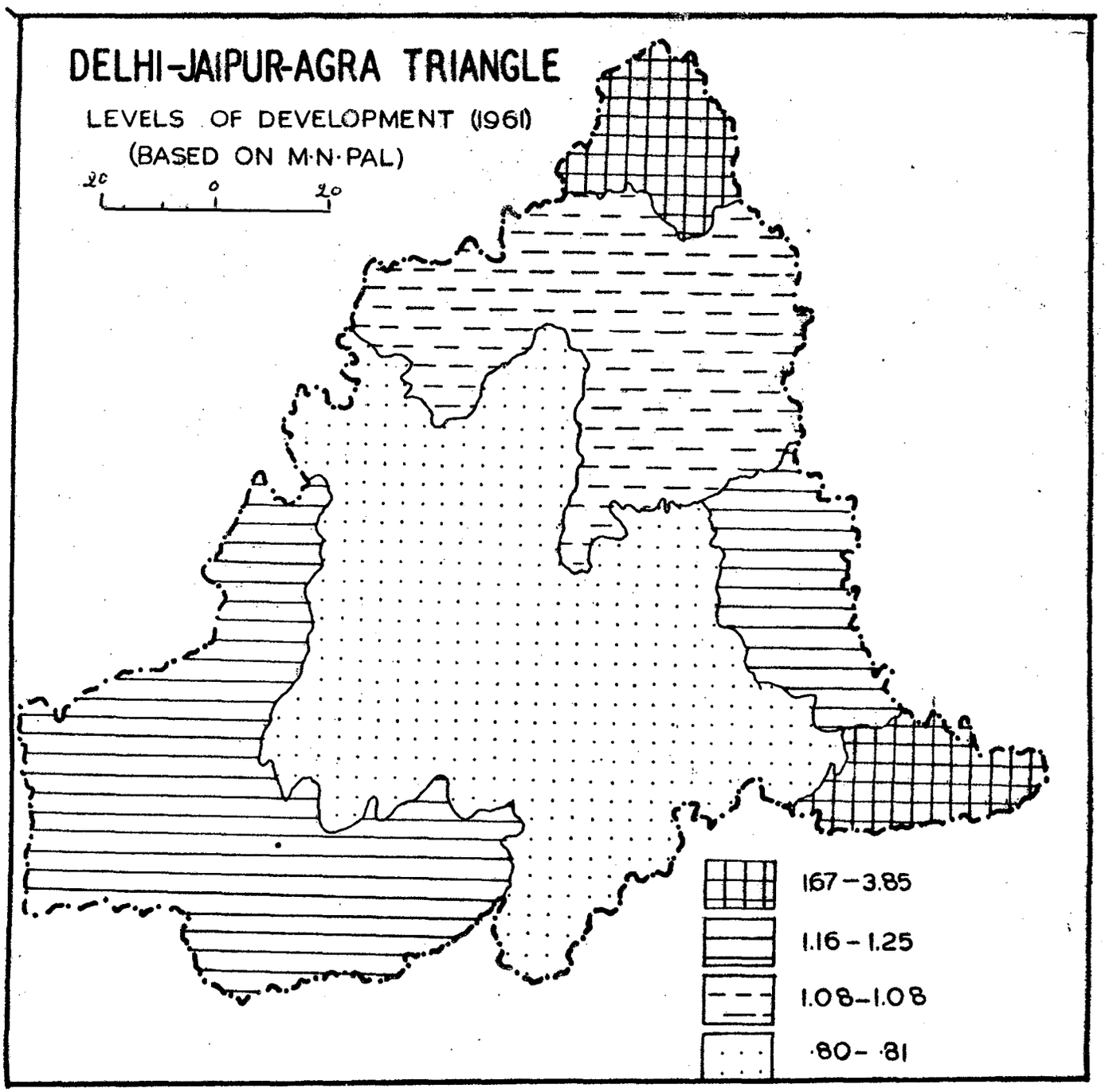
DELHI-JAIPUR-AGRA TRIANGLE
LEVELS OF DEVELOPMENT (1961)
(BASED ON M·N·PAL)
20 0 20
1·67 – 3·85
1.16 – 1.25
1.08 – 1.08
·80 – ·81

Fig 2.6

M.N. Pal's index of development shows that Delhi in the north and Agra in southeast have very high level of development. According to Asok Mitra also they fall in the same level. Both these are located at the national highway junctions. Mathura which is located at the extreme eastern side of the region and Jaipur in southwest have high level of development according to M.N. Pal but have very high level of development according to A. Mitra. The index calculated by M.N. Pal shows that the heart of the region (which covers almost half of the total area) has low level of development, which in the composite index prepared by Asok Mitra falls in the high level of development. Most of the area of this continuous zone is chilly and uneven (particularly the western half of it). In the north of this zone and south of Delhi is the zone of medium level of development according to M.N.Pal, which according to Asok Mitra falls in the category of high level of development.

The difference in the two methods can be explained in terms of their approach, while Asok Mitra's index gives simple ranks to the indicators of development, M.N. Pal gives weightages to the indicators and calculates the composite index, which makes this method more quantitative and precise. Hence M.N. Pal's findings of the levels of development of the districts under study have been taken into account in our text to relate them with the transport indicators of development in a subsequent portion of the text. For our convenience in map No.21 we have put M.N. Pal's exceptionally high and very high levels in one category, which we call high level of development. His high level of development, medium level of development and low level of development we shallbe calling medium, low and very low level of development respectively.

V. An Introduction to Road Accessibility in the Region:

The Delhi-Jaipur-Agra triangle has 7448 settlements. In this section a brief introduction has been given to their distance from the metalled roads.

The settlements in this region seem to be highly accessible with respect to roads. Nearly 63% of the settlements are within a distance of 2 miles from the roads. However, there are wide variations in tehsils with respect to the percentage of settlements within 2 miles from the road, which vary from 32 in Chhata to 96 in Ferozepur Jhirka (Table No.6). In northern part of the region (in all the tehsils of district Gurgaon and Delhi), more than 90% of the settlements are within two miles from the roads. Most of the tehsils which have less than 50% villages within two miles from the roads fall in the south-western part of the region and make a contiguous belt over uneven topography. 70% of the tehsils of the region have more than 50% settlements within 2 miles from the roads. Nearly 32 per cent of the settlements of the region are at a distance of 2 to 4 miles away from the roads. Ferozepur Jhirka has only 3.71 per cent (minimum) of settlements from 2 to 4 miles away from the roads (Table No.6), Kirauli tehsil has 60.35 per cent (maximum) of the settlements within a distance from 2 to 4 miles from the roads. There are only 6 tehsils where more than 50% villages fall within a distance of 2-4 miles from the roads. These tehsils don't make a contiguous region and are scattered in the southwest, mid-southwest, southeast and east of the region.

Table No. 4

Road Accessibility

S. No.	Tehsil	No. of villages within two miles of the roads	No. of villages 2-4 miles away from the roads	No. of villages more than 4 miles away from the roads	%age of villages within two miles of the roads	Percentage of villages 2-4 miles away from the roads	Percentage of villages more than 4 miles away from the roads
1.	Delhi	236	22	-	91.97	8.52	-
2.	Gurgaon	212	12	-	94.64	5.35	-
3.	Rewari	403	22	-	94.82	5.17	-
4.	Ballabgarh	182	21	-	89.65	10.34	-
5.	Palwal	185	12	-	93.90	6.09	-
6.	Nuh	262	27	-	90.65	9.34	-
7.	F.Jhirka	233	9	-	96.28	3.71	-
8.	Chhata	53	85	25	32.51	52.14	15.33
9.	Mathura	130	91	5	57.52	40.26	2.21
10.	Bharatpur	211	70	5	73.77	24.47	1.74
11.	Nadbai	93	16	5	81.57	14.03	4.38
12.	Weir	=35	16	-	89.40	10.59	-
13.	Kaman	171	87	10	66.27	93.72	3.67
14.	Nagar	109	53	10	63.37	30.61	5.81
15.	Deeg	75	39	5	63.02	32.77	4.20
16.	Mahwa	85	67	-	55.92	44.07	-
17.	Toda Bhim	87	49	5	61.70	34.75	3.54
18.	Jaipur	52	43	5	52.00	43	5.00
19.	Amber	103	75	40	47.24	34.40	18.34
20.	Sikrai	96	30	10	70.58	22.05	7.35
21.	Dausa	97	137	35	40.41	57.08	14.58
22.	Baswa	58	80	30	34.52	47.61	17.85
23.	Kotputli	52	52	18	42.62	42.62	14.75
24.	Bassi	107	98	5	50.95	46.66	2.38
25.	J. Ramgarh	101	117	40	39.14	45.34	15.50
26.	Bairath	57	62	15	41.59	46.26	11.19
27.	Alwar	207	134	15	57.98	37.64	4.21
28.	Kishangarh	128	94	-	57.65	42.34	-
29.	Mandawar	96	37	-	72.18	27.81	-
30.	Thanaghazi	65	79	8	42.76	51.97	5.26
31.	Bansur	76	38	10	61.29	30.64	8.06
32.	Rajgarh	171	65	10	69.51	26.42	4.06
33.	Lachhmangarh	174	143	4	54.20	44.54	4.67
34.	Behror	108	55	15	60.67	30.89	8.42
35.	Tijara	141	67	-	67.78	32.21	-
36.	Agra	-	79	-	40.60	59.39	-
37.	Kirauli	67	102	-	39.64	60.35	-

Hardly 5% of the settlements of the region are located more than 4 miles away from the roads. Tehsils of district Gurgaon and Delhi in the north, Kirauli and Agra tehsils in southeast do not have any village which is more than 4 miles away from the roads. The values range from 1.74% in Bharatpur tehsil (minimum) to 18.34% in Amber (maximum). In the tehsils in southwest of the region (the areas which have hilly and forested topography) the percentage of those villages which are more than 4 miles away from the roads is higher (ranging from 4 to 18%).

The road development plan of 1961-81* lays down the following proposed distances of settlements from a metalled or any other road in areas with different levels of development.

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* A road development plan was submitted in 1958 by the Committee of Chief Engineers to study the development of road construction made in this country. The following points were taken in consideration while preparing this 20 year road development plan; (a) Need of semi-developed and undeveloped areas, including forest areas, in addition to the needs of highly developed and agricultural areas; (b) location of administrative headquarters, places of pilgrimage, health resorts, tourist centres, universities and cultural centres; (c) location of industries, important commercial centres, big railway junctions and ports; and (d) the strategic needs of the country. Taking in account the future requirements of the different types of areas in the country, the Committee has laid down the maximum proposed distances of roads from them as given below

Maximum distance (miles) of any place

Description of area	Norm		Mileage per 100 sq. miles of area
	From a metalled road	From any road	
Developed & Agr.Area	4	1.5	70
Semi-developed area	8	3.0	30
Undeveloped and uncultivable area	12	5.0	19

But it is difficult to test the norms without exactly knowing how the Committee proposed to identify the areas into Developed and Agricultural Area, Semi-Deveoped Area and Undeveloped and Uncultivable Area, as the information regarding it could not be obtained.

CHAPTER II

LEVELS OF ROAD NETWORK DEVELOPMENT

GRAPH THEORY TECHNIQUE FOR NETWORK ANALYSIS:

Fundamental concepts of graph theory facilitates recognition of relations between seemingly non-correlated elements of transport network. The graphs are defined as arrangement of points which are connected or not connected to one another by straight lines corresponding to the original network. Disregarding the exact difference between the network's vertices the graph may be redrawn in a more abstract way. The points and lines may be assigned with individual numerical values which represent the magnitude; i.e. the values attached express the length of each route. Thus graph is simplified representation of network.

Planer and non planer graphs:

(1) Planer graphs: in these graphs all the intersections of edges are junctions and considered as vertices. These graphs are in a single plane.

(2) Non planer graphs: In non planer graphs edges can cross without any junction, for example, as in some railways. Most of our railways and roads make planer graph, whereas airways make non planer graph.

Graph theory provides the language to define the topological properties of the network. The theory deals with

abstract configurations consisting of points and lines.

Graph theoretic measures of network structure can be derived if we simplify the transport network into a graph. The following three symbols may be noted from this simplified graph:

1. Each crossing of routes or terminus is considered as vertex (V)
2. The route joins the two vertices is called edge by (e)
3. Number of subgraphs or subsidiary networks are denoted by p.

Based on these three properties of graph all the following mentioned non-ratio and ratio measures of network as a whole, have been derived.

1. Cyclomatic Number: This is a fundamental index (non-ratio) of the graph theory. The cyclomatic number indicates the number of circuits* in a transport network. This may be calculated by the following formula:

$$\mu = e - v + p$$

(E, V, and P are as defined earlier)

Any disconnected or tree shaped network has zero cyclomatic number. On the other hand, highly connected network has higher values for u. It has been observed that under-developed countries have tree or disconnected graph-shaped network and developed countries have highly connected transportation network. This shows that cyclomatic number is a very useful indicator of transport network structure. The greatest drawback is that it

* Circuit is a path where we start from a particular place (vertex) and back to the same vertex without crossing any of the edges more than once.

does not consider the shape and size of the region. For example, it is economical to connect the alongated region by some linear fashion. If the vertices are more possibly the circuits also may be more, thus the comparison of two different sizes of networks is not possible.

2. Alpha: This is an adjusted form of the cyclomatic number. Its formula is given below.

$$\alpha = \frac{\mu(e-v+p)}{\frac{V(V-1)}{2} - (V-1)}$$

e stands for edges or routes, V stands for vertex, p. stands for the number of isolated subgraphs. The formula may be interpreted as it is the ratio between the actual circuits and total possible circuits in a given area. In the above equation u denotes the actual number of circuits and denominator is equal to the total maximum possible circuits in the region. According to this index connectivity values will range from zero to one. For completely inter-connected network (i.e. maximum number of edges) the value will be one. As the edges decrease the connectivity value will go on decreasing towards zero. The value will be zero for the network which has no circuit. Thus the index is independent of the number of vertices in the network. The advantage of this index is that we can compare two networks of equal or unequal sizes.

3. Beta: This expresses the relationship between edges (routes) and vertices of a given network. Mathematically it can be expressed as

$$B = \frac{e}{v}$$

B for developed network will have higher values, tree like or disconnected network will have less values, less than unity and the network which has one circuit only will have unity as its value. Better developed network has more than value more than unity. The index is affected by shape and size of the area.

4. Gama: This denotes ratio between edges and vertices and may be expressed by the following formula.

$$r = \frac{e}{\frac{V(V-1)}{2}}$$

(This formula indicates the ratio between edges and total possible vertices).

Since gaga index is relative, its comparison between two networks is possible. The values of this index varies from zero to one. The most developed index will have the value of one. This index is independent of vertices. According to the index value one will be assigned to all the completely connected networks irrespective of the number of vertices they have.

5. Eta: This is the ratio between total road mileage of an area and total number of edges in that area. This expresses relationship between the transportation network as a whole and its routes as individual elements of network. Eta may be expressed by the following formula:

$n = M/e$, where e denotes edges and M stands for total mileage of the network. It has two drawbacks; first that it does not take into account the number of vertices,

hence subjected to size variations, and second that it is dependent on the spatial distribution of the vertices. This is a negative indicator. Higher value indicates lower development and vice versa.

6. Theta: This is the ratio of the network as a whole to its vertices and may be expressed as $\theta = M/v$. This represents average length of edge per vertex. Its main property is that it offers information about length, structure and also on the degree of connectivity simultaneously. The disadvantage is that the comparison is not possible when the networks of regions have different shapes, and distribution of vertices is different. It is evident that all these reasons are abstract in that the geographical magnitude of the network is ignored when all edges are arbitrarily assigned value one.

7. Road Density: Road density also has been taken as an indicator of road network development. The total road mileage of the network has been divided by the area of that region.

8. H Index: This index shows the accessibility with respect to national highway. The distance of the least accessible village from the national highway has been measured. Higher the value, lower the accessibility of a tehsil would be.

This index is important because of two reasons: (1) since our area of study is "The national highway triangle of Delhi-Jaipur-Agra", there should be some indicator to reflect the national highway. (2) The second reason which is of greater

significance is that the particular roads which may be district roads, village roads or any other category of the roads, are not independent systems. These tributary and feeder roads utlimately join the national highway. Thus through the link roads the whole region is brought in the national picture. In this way, looking at the overall network system of a region, the accessibility of a tehsil or area from the national highway is very important.

The H index has been calculated from the key map of road network. From each tehsil a least accessible village (from the national highway) has been taken and its distance measured from thesame. Tehsils which have higher values mean that they are least accessible and vice-versa.

9. Q Index: This is the index of settlement connectivity, where the definition of connectivity is somewhat different. If any village is slightly away from the road one must not call it as absolutely unconnected. So some importance should be given to those settlements which are nearer to the roads. We have taken this limit as two miles away from the roads.

Another important aspect of this index is the size of different villages. Suppose there are two villages; one is big and the other one is small, big village has a better chance to be connected earlier. Now if they are being connected at the same time, the bigger village should be given some penalty which can emphasize this degree of disadvantage, resulted in because of its being connected later. Contrary to it more and

Table No. 5

S. No.	Tehsil	1 — A. Villages on the Roads (of six categories) I	II	III	IV	V	VI	1 — %age of the villages to the total villages of that class I	II	III	IV	V	VI	2 — Villages within two miles of the roads I	II	III	IV	V	VI	2 — %age of villages to the total villages of that class I	II	III	IV	V	VI
1.	JAIPUR	2	5	1	2	0	0	0.030	0.217	0.125	0.400	0.000	0.000	24	9	6	3	0	0.00	0.369	0.391	0.750	0.600	0.000	0.000
2.	AMBER	3	7	4	5	1	0	0.028	0.137	0.125	0.416	0.500	0.000	43	20	17	2	1	0.00	0.401	0.392	0.531	0.166	0.500	0.000
3.	SIKAR	6	1	0	2	1	0	0.092	0.023	0.00	0.500	1.000	0.000	43	29	14	0	0	0.00	0.661	0.690	0.700	0.000	0.000	0.000
4.	DAUSA	12	1	4	1	0	0	0.077	0.019	0.173	0.142	0.000	0.000	51	23	3	1	1	0.79	0.331	0.450	0.130	0.142	1.000	0.000
5.	BASWA	2	4	2	2	0	0	0.022	0.088	0.100	0.285	0.000	0.000	29	10	8	1	0	0.48	0.322	0.222	0.400	0.42	0.000	0.000
6.	KOTPUTLI	5	4	11	3	0	0	0.029	0.093	0.366	0.250	0.000	0.000	12	12	7	2	0	0.33	0.352	0.279	0.233	0.166	0.000	0.000
7.	BASSI	7	4	4	3	0	0	0.048	0.137	0.333	0.500	0.000	0.000	66	16	4	3	0	0.89	0.458	0.551	0.333	0.500	0.000	0.000
8.	JAMWA RAMGARH	11	4	3	1	1	0	0.078	0.065	0.120	0.083	0.500	0.000	42	26	8	4	1	0.81	0.297	0.426	0.320	0.333	0.500	0.000
9.	BAIRATH	2	3	2	4	1	1	0.041	0.100	0.083	0.222	0.333	1.000	11	11	16	6	0	0.44	0.229	0.366	0.666	0.333	0.000	0.000
10.	ALWAR	20	10	1	4	1	0	0.094	0.135	0.025	0.266	1.000	0.000	106	39	20	6	0	0.171	0.502	0.527	0.500	0.450	0.000	0.000
11.	KISHANGARH	7	10	3	2	0	0	0.058	0.142	0.166	0.285	0.000	0.000	64	31	8	3	0	0.106	0.533	0.442	0.444	0.428	0.000	0.000
12.	MANDAWAR	5	3	7	2	0	0	0.116	0.054	0.291	0.285	0.000	0.000	29	35	11	4	0	0.79	0.674	0.636	0.458	0.571	0.000	0.000
13.	THANAGHAZI	7	6	3	1	0	0	0.084	0.214	0.176	0.142	0.000	0.000	28	11	6	3	0	0.480	0.337	0.392	0.352	0.428	0.000	0.000
14.	BANSUR	4	5	3	1	1	0	0.074	0.128	0.125	0.200	0.500	0.000	25	21	13	3	0	0.62	0.462	0.538	0.541	0.400	0.000	0.000
15.	RAJGARH	23	5	7	5	0	0	0.153	0.096	0.233	0.454	0.000	0.000	82	30	15	4	0	0.131	0.546	0.576	0.500	0.363	0.000	0.000
16.	LACHHMAN-GARH	16	11	0	3	1	0	0.100	0.106	0.000	0.166	1.000	0.000	73	44	17	9	0	0.143	0.459	0.427	0.459	0.500	0.000	0.000
17.	BEHROR	10	9	6	2	1	0	0.196	0.152	0.120	0.222	1.000	0.000	22	28	27	3	0	0.80	0.431	0.474	0.540	0.333	0.000	0.000
18.	TIJARA	17	9	2	3	0	0	0.134	0.176	0.142	0.750	0.000	0.000	79	21	9	1	0	0.110	0.626	0.411	0.642	0.250	0.000	0.000
19.	TODABHIM	6	9	1	1	0	0	0.085	0.250	0.043	0.125	0.000	0.000	35	18	12	5	0	0.70	0.500	0.500	0.521	0.625	0.000	0.000
20.	MAHWA	8	6	5	3	0	0	0.088	0.206	0.217	0.500	0.000	0.000	42	12	8	1	0	0.63	0.466	0.413	0.347	0.166	0.000	0.000
21.	DELHI	8	9	12	32	3	1	0.173	0.183	0.160	0.551	0.500	0.500	38	40	63	26	3	1.171	0.826	0.816	0.840	0.448	0.500	0.500
22.	BALLABGARH	21	33	30	17	3	0	0.338	0.687	0.681	0.772	0.000	0.000	41	15	14	5	3	0.78	0.661	0.312	0.318	0.227	0.500	0.000
23.	GURGAON	29	31	37	11	4	0	0.439	0.455	0.649	0.647	1.000	0.000	37	37	20	6	0	0.100	0.560	0.544	0.350	0.352	0.000	0.000
24.	NUH	45	20	21	19	3	0	0.348	0.338	0.446	0.791	1.000	0.000	84	39	26	5	0	0.154	0.651	0.661	0.553	0.208	0.000	0.000
25.	F.JHIRKA	47	39	24	7	3	0	0.405	0.590	0.615	0.777	1.000	0.000	69	27	15	2	0	0.113	0.594	0.409	0.384	0.222	0.000	0.000
26.	PALWAL	20	28	18	5	7	0	0.392	0.430	0.428	0.263	0.975	0.000	31	37	24	14	1	0.107	0.607	0.569	0.571	0.736	0.125	0.000
27.	REWARI	42	58	29	15	0	0	0.283	0.362	0.397	0.714	0.000	0.000	106	102	44	6	1	0.259	0.716	0.637	0.602	0.285	1.000	0.000

1 Process of Q Index

2

Table No.

Process of Q Index

S. No	Tehsil	3 After giving the weight to villages on the roads							4 After giving ½ weight to villages within two miles of the roads							
		I	II	III	IV	V	VI	Total	I	II	III	IV	V	VI	Total	Q. Index
1.	Jaipur	.578	4.149	3.253	7.038	0	0	15.019	3.559	3.737	6.979	5.278	0.000	0.000	19.553	34.572
2.	Amber	0.540	2.619	2.326	7.320	7.614	0	20.419	3.867	3.747	4.941	1.460	3.807	0.000	17.822	38.241
3.	Sikrai	1.774	0.439	0.000	8.798	15.228	0	25.239	6.375	6.596	6.514	0.000	0.000	0.000	19.485	44.724
4.	Dausa	1.485	0.363	3.219	2.498	0	0	7.565	3.192	4.302	1.209	1.249	7.614	0.000	17.566	25.131
5.	Baswa	0.424	1.682	1.861	5.015	0	0	8.982	3.105	2.122	3.722	3.695	0.000	0.000	12.644	21.626
6.	Kotputli	0.559	1.778	6.911	4.399	0	0	13.547	3.395	2.667	2.168	1.460	0.000	0.000	9.690	23.237
7.	Bassi	0.925	0.707	6.197	8.798	0	0	16.627	4.417	5.267	3.098	4.399	0.000	0.000	17.181	33.808
8.	J.Ramgarh	1.504	1.242	2.233	1.460	7.614	0	14.053	2.864	4.072	2.977	2.929	3.807	0.000	16.649	30.702
9.	Bairath	0.790	1.912	1.544	3.906	5.070	10.152	23.374	2.208	3.498	6.197	2.929	0.000	0.000	14.832	38.206
10.	Alwar	1.813	0.669	0.465	4.680	15.228	0	22.855	4.841	5.038	4.653	3.519	0.000	0.000	18.051	40.906
11.	Kishangarh	1.118	2.715	3.089	5.015	0	0	11.937	5.140	4.225	4.131	3.765	0.000	0.000	17.261	29.198
12.	Mandawar	2.37	1.032	5.416	5.015	0	0	13.832	6.500	6.080	4.262	5.023	0.000	0.000	21.865	35.698
13.	Thanaghazi	1.620	4.091	3.275	2.498	0	0	11.484	3.250	3.747	3.235	3.765	0.000	0.000	14.037	25.521
14.	Bansur	1.427	2.447	2.326	3.519	7.614	0	17.333	4.455	5.143	5.034	3.519	0.000	0.000	18.151	35.484
15.	Rajgarh	2.951	1.835	4.336	7.989	0	0	17.111	5.266	5.506	4.653	3.191	0.000	0.000	18.618	35.729
16.	Lachhmangarh	1.929	2.026	0.000	2.921	15.228	0	22.104	4.427	4.082	4.271	4.399	0.000	0.000	17.179	39.283
17.	Behror	3.781	2.906	2.233	3.906	15.228	0	28.054	4.156	4.531	5.025	2.929	0.000	0.000	16.641	44.695
18.	Tijara	2.584	3.365	2.642	13.197	0.000	0	21.788	6.037	3.929	5.974	2.199	0.000	0.000	18.139	39.927
19.	Toda Bhim	1.639	4.780	0.800	2.199	0.000	0	9.413	4.822	4.780	4.848	5.498	0.000	0.000	19.948	29.361
20.	Mahwa	1.697	3.938	4.038	8.798	0.000	0	18.471	4.494	3.948	3.229	1.460	0.000	0.000	13.131	31.602
21.	Delhi	3.337	3.498	2.977	9.695	7.614	5.076	32.197	7.966	7.800	7.817	3.941	3.807	2.538	33.869	66.066
22.	Ballabgarh	6.520	13.135	12.674	13.584	7.614	0	53.527	6.375	2.982	2.959	1.997	3.807	0.000	18.120	71.647
23.	Gurgaon	8.468	8.699	12.079	11.385	15.228	0	55.859	5.401	5.200	3.257	3.096	0.000	0.000	16.954	72.813
24.	Nuh	6.713	6.462	8.300	13.919	15.228	0	50.622	6.278	6.319	5.146	1.829	0.000	0.000	19.572	70.194
25.	F. Jhirka	7.812	11.280	11.446	13.672	15.228	0	59.438	5.729	3.910	3.573	1.953	0.000	0.000	15.165	74.603
26.	Palwal	7.92	8.221	7.965	4.628	14.843	0	43.581	5.854	5.439	5.313	6.475	0.951	0.000	24.032	67.613
27.	Rewari	5.459	6.921	7.388	12.564	0	0	32.332	6.905	6.089	5.602	2.507	7.614	0.000	28.717	61.049

more weightage should be given to smaller and smaller villages. Above mentioned facts have been reflected by the Q index, which has been calculated by the following way. In the first step of calculation all the settlements in the region have been put in three categories according to the distance from the roads; (1) the villages on the roads (2) villages within two miles of roads (3) villages more than two miles away from the roads. Villages more than two miles away from the roads were considered unconnected.

Another step was to classify the villages in six categories* according to their size. The villages on the roads were put in table number 5 and villages within two miles from the roads were put in table number 5. The villages located on the roads have been divided by the total number of villages of that class in a particular tehsil, thus making the figures comparable. Similarly the villages within two miles from the roads (as given in table number 5) were processed.

The next stage was how to give the weightage to a particular size of village. As mentioned earlier the villages were classified in six categories according to the population. The mid values were taken for all the six classes and these values have been arranged in ascending order (highest value at the top and lowest in the bottom). The cumulation figures

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* These six classes of village are based on census of India classification.

were arrived at in such a way that with gradual decrease in actual figure (mid values of different classes), resulted in gradual increase in cumulative values. The percentage for each cumulative value with its total has been calculated. The percentage for each cumulative value with its total has been calculated. The percentages were taken as the weightages* for the respective classes of villages, highest weight being for the lower most size of villages. The percentage of different villages in different tehsils (class wise) were multiplied by these weightages.

A similar process has been adopted for the villages which are within two miles of the roads with the exception of the fact that the weightages given were half of those which were given to the villages located on the roads. After allotting the weightages all the twelve values of both tables were added for each tehsil. This became the value of Q index for that particular tehsil.

While preparing indices of road network development vertices and subgraphs were calculated in different way. All the settlements in a tehsil and crossing or terminus of routes were considered vertices. Apart from subgraphs of road network,

---

* The following formula has been worked out for giving weightages:

$$Wj = \frac{CMVj}{\sum_{J} CMVJ}$$

CMVj = cumulative mid value of the class size from above in jth class
Wj = weightage assigned to jth class
EcMV = Sum of CUMUJ's (J = 1,2....m)
m = total number of classes.

all other settlements away from the roads were also considered as subgraphs. The reason is that on this basis we take in consideration the overall situation of a unit area. Afterall the ultimate objective is to connect all the settlements of a given area. On this basis we can take in consideration all the settlements whether they are on the roads or not.

EFFECTIVENESS OF DIFFERENT INDICATORS

In figure 3 the effectiveness* of above indicators has been mapped. From this map the position of each index in each tehsil can be seen.

It is noted that all these indicators are not equally effective in each and every tehsil. On the basis of shape and size of polygons (which indicate effectiveness of various indicators) the whole region may be divided roughly in following three zones.

I. The first zone includes Delhi and tehsils of Haryana. Two things are noted in this zone:

(i) The polygons are of large size, which indicate the high level of network development.

(ii) Secondly, in this zone of high level of network development, cyclomatic number and Alpha indices are most dominating and effective.

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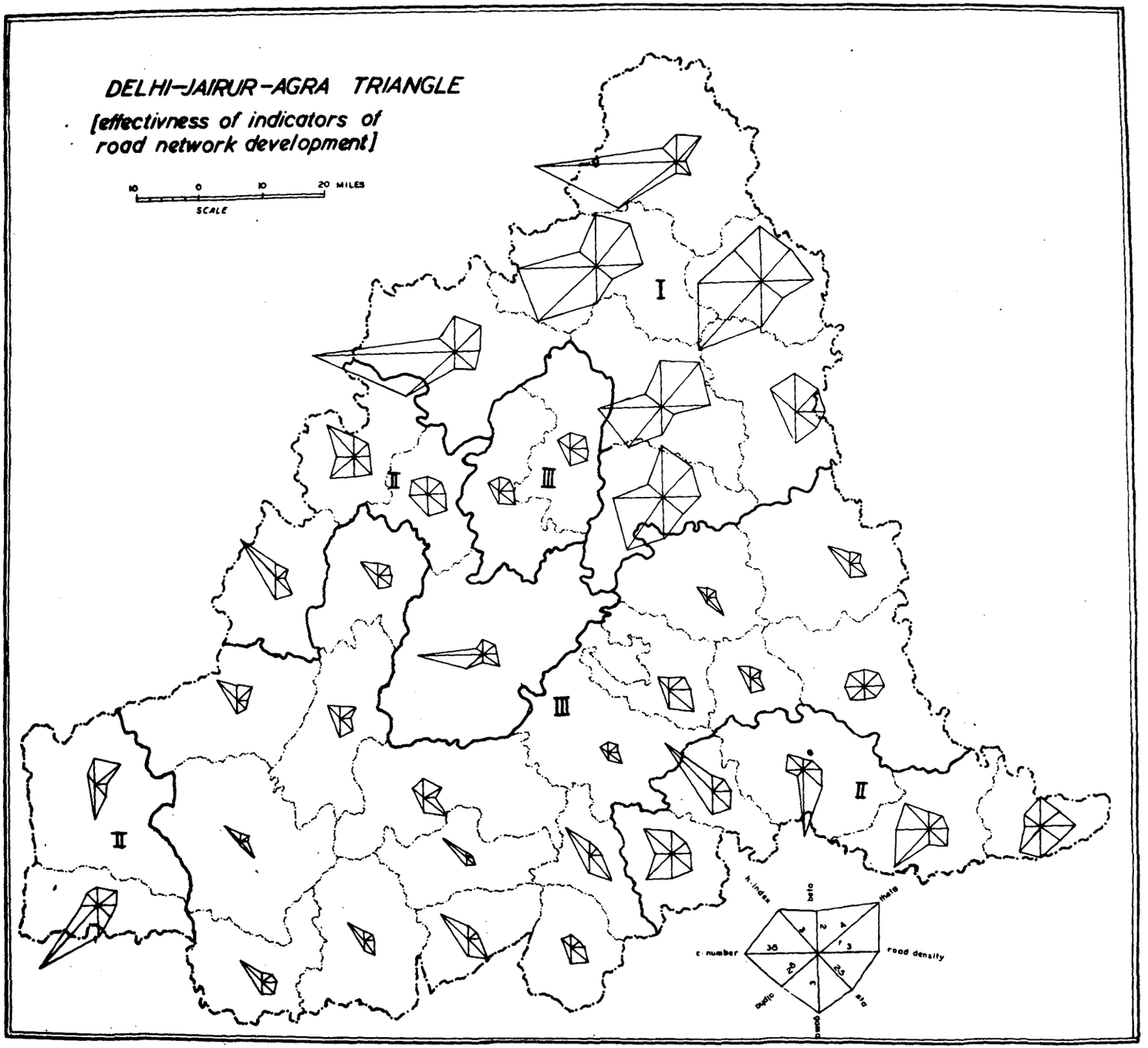
* (1) In order to show the effectiveness of indicators, scale free values have been shown by lines in definite directions having a common scale.

(2) Only eight indicators have been shown in this map and Q index has been avoided because it was calculated only for 27 tehsils due to data limitation.


DELHI–JAIRUR–AGRA TRIANGLE
[effectivness of indicators of road network development]
10 0 10 20 MILES
SCALE
I
II
III
III
II
II
c : number
road density

FIG·3

These two indices are dominating because the zone has got very complicated road network, which is responsible for more circuits in the said zone. Alpha is effective because it depends mainly on the circuits observed in a particular region.

(iii) Lastly, all other indicators are also not so weak in this zone, except Delhi.

II. The tehsils of medium size polygons are fragmented in three sub-regions. The tehsils of these sub-regions can be further grouped under two categories:

Firstly, the tehsils where particular indicators are dominating and most effective. For example, in Bharatpur, gama is most effective, in Nadbai and Kotputli H index plays dominating role, in Jaipur alpha ismost effective, in Alwar tehsil cyclomatic number is more important. The remaining tehsils of this category comes in second group where polygons are almost regular and domination of particular index is not so much.

III. In this category there are sub-regions where the polygons are of very small size, showing lowest level of road network development. Except Tijara and Kishangarh all other tehsils make a contiguous region extending from west to east in southern half of the region. The H index is very much effective in all those tehsils which are crossed by national highway. Throughout this southern zone the regularity of polygons is disrupted mainly by the effectivenss of H index.

Table No. 6

Inter - Correlation matrix

	M	r	α	Dn	β	n	Theta	Q	H	C.I.
M	1	.40	.98	.66	.71	-.40	.69	.26	.07	.82
r		1	.48	.55	.62	-.18	.51	-.18	-.26	-69
α			1	.67	.74	-.02	.65	.30	.04	.81
Dn				1	.77	-.32	.66	.26	-.03	.71
β					1	-.37	.88	.-86	-.10	.86
n						1	-.01	-.99	.39	-.33
Theta							1	.35	.10	.71
Q								1	-.72	.67
H									1	-.27
C.I.										1

VALIDITY OF THE INDICATORS TAKEN IN STUDY

In order to see the validity of the indicators taken in this study the inter correlation matrix of the said indicators has been prepared. Those indices which have not significant correlations, particularly the structural indices, have been elininated from the study. The attached(Table No.( ) matrix shows that out of 36 sets of correlations 24 are positively correlated. The following are positively correlated at high % level of significance.

Cyclamatic number and Alpha	.98
Beta and Theta	.88
Road Density and Beta	.77
Beta and Alpha	.74
Beta and Cyclamatic Number	.71
Cyclamatic Number and Theta	.69
Alpha and Road Density	.67
Cyclamatic Number and Road Density	.66
Road Density and Theta	.66
Alpha and Theta	.65
Beta and Gama	.52
Gama and Road Density	.55
Gama and Theta	.51

The lowest correlation value is .04 for Alpha and National Highway accessibility, which shows that the said two variables have no correlation. The following sets are negatively significant in their correlations:

Settlement Index and Eta	.99
Settlement Index and National Highway accessibility	.72
Cyclamatic Number and Eta	.40
Beta and Eta	.37
Road Density and Eta	.32

National Highway accessibility and Eta are both negative indicators and hence their correlation is positive with r value .39.

If we see the correlation of these variables with composite index of road network development we found that cyclamatic number, Gama, Alpha, Road density, Beta, Eta, Theta, Settlement Index (Q index) H index (National Highway accessibility) have r value .82, .69, .81, .71, .86, -.33, .71, .67, -.27 respectively. Correlation values are very high among Beta and composite index, cyclamatic number and composite index, Alpha and composite index. This shows that those three variables are the greatest contributor in formation of the composite index (which indicates the level of road network development).

Composite Index:

Cyclamatic Number, Beta, Alpha, Gama, Eta, Theta, Road Density, National Highway accessibility Index (H Index) settlement connectivity index (Q index) were taken for compositing together. The attached table number 7 shows the value of different indicators tehsilwise. Mean value has been

calculated for each indicator. The values of all the indicators for each tehsil were divided by their respective means except Eta and H Index (which are negative indicators) where the mean has been divided by the actual figures. Thus we arrived at new figures which were scale free and added up all the scale free values and lastly divide the total score of each tehsil by number of indicators taken there in the study. By this process we got the composite index showing the levels of road network development.

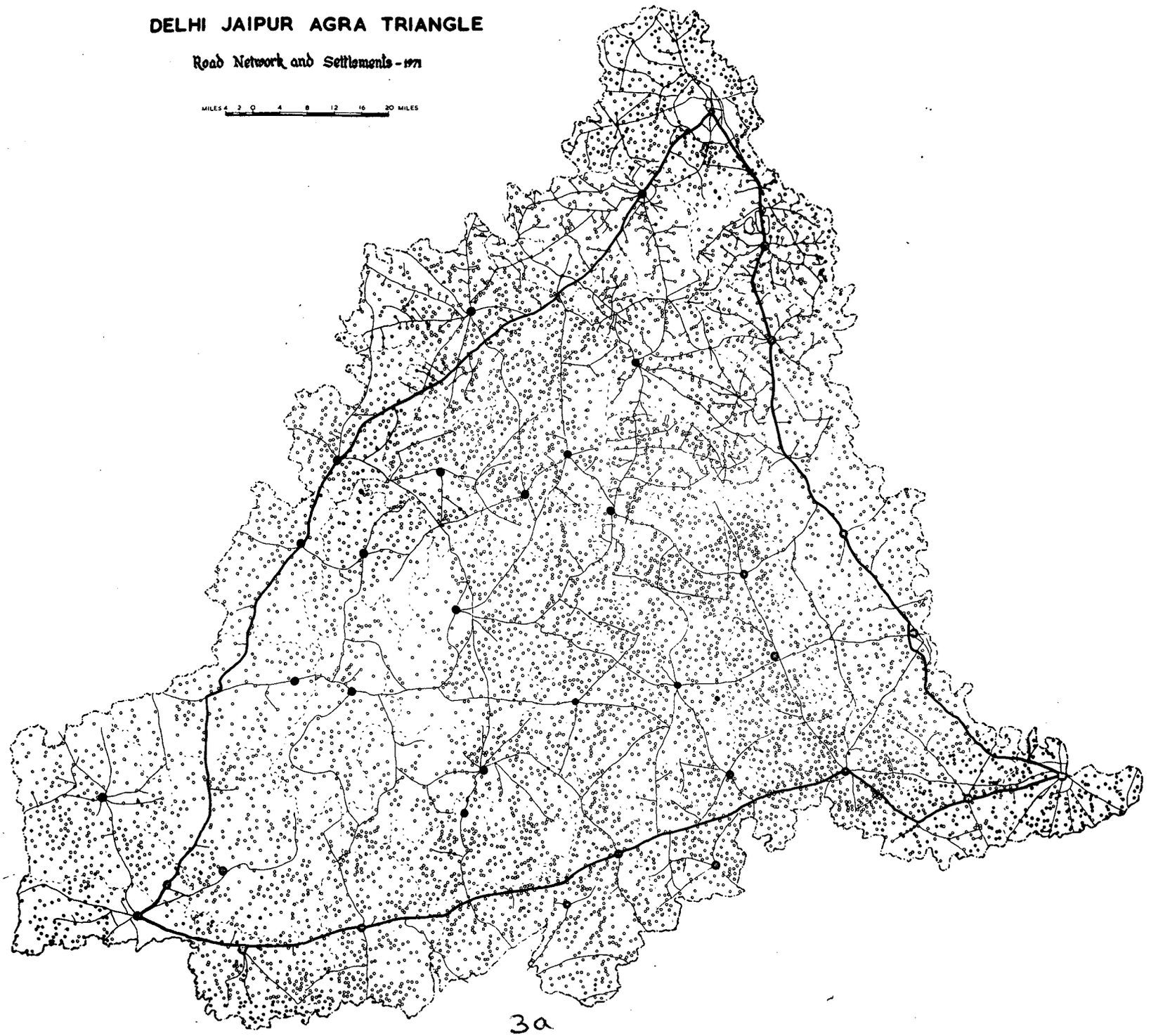
Types of existing Road Network in the Region

Before analysing the actual composite index of network development, it would be interesting to throw some light on the general features of the transport network of this region. If we see the whole region we find different types of road networks ranging from very simple to complicated ones. The whole northern part (Map No.3a) of the region is appearing like a thick net of roads. If we proceed southwards from Haryana we find some abrupt change in the road development particularly in case of district Jaipur and Alwar. For example, Kishangarh and Tijara tehsils are just along Rewari and Ferozepur Jhirka, but their road network is very poor as compared to latter ones. Another point is that the Aravalli range and its surroundings have very poor network. Just looking at Amber, Thanagazi, Jamwa Ramgarh, Behror and Western part of Alwar, Dausa and Sikrai, the road network is very poor, at the same time the settlements are also very few, which is the direct effect of physiography. Among the four tehsils ofU.P. Agra has better road network. The actual road network has been simplified in Map No.4,5.

DELHI JAIPUR AGRA TRIANGLE

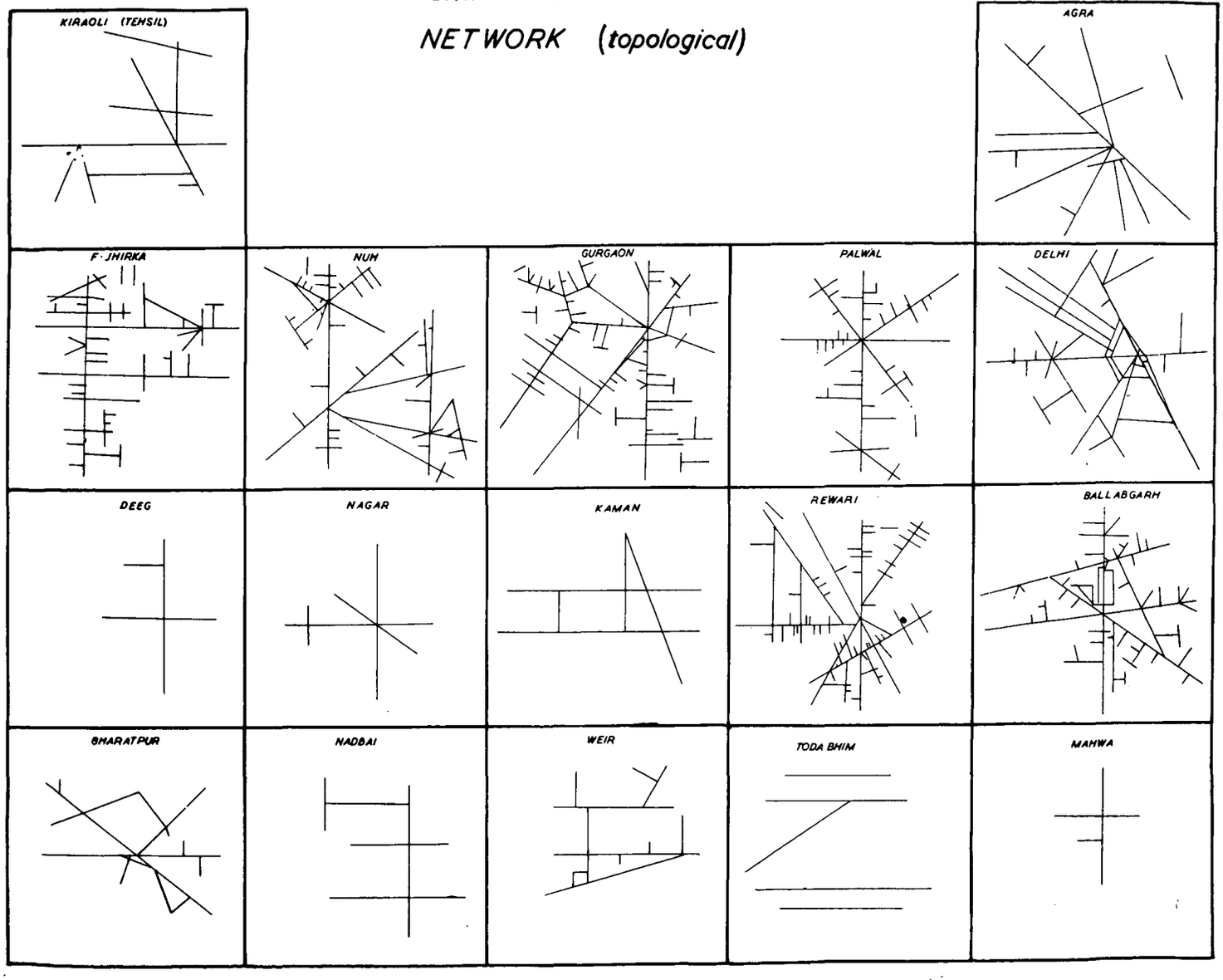
Road Network and Settlements - 1971

MILES 4 2 0 4 8 12 16 20 MILES



3a

SIMPLIFIED ROAD NETWORK (topological)



FIG·4

SIMPLIFIED ROAD NETWORK [topological]

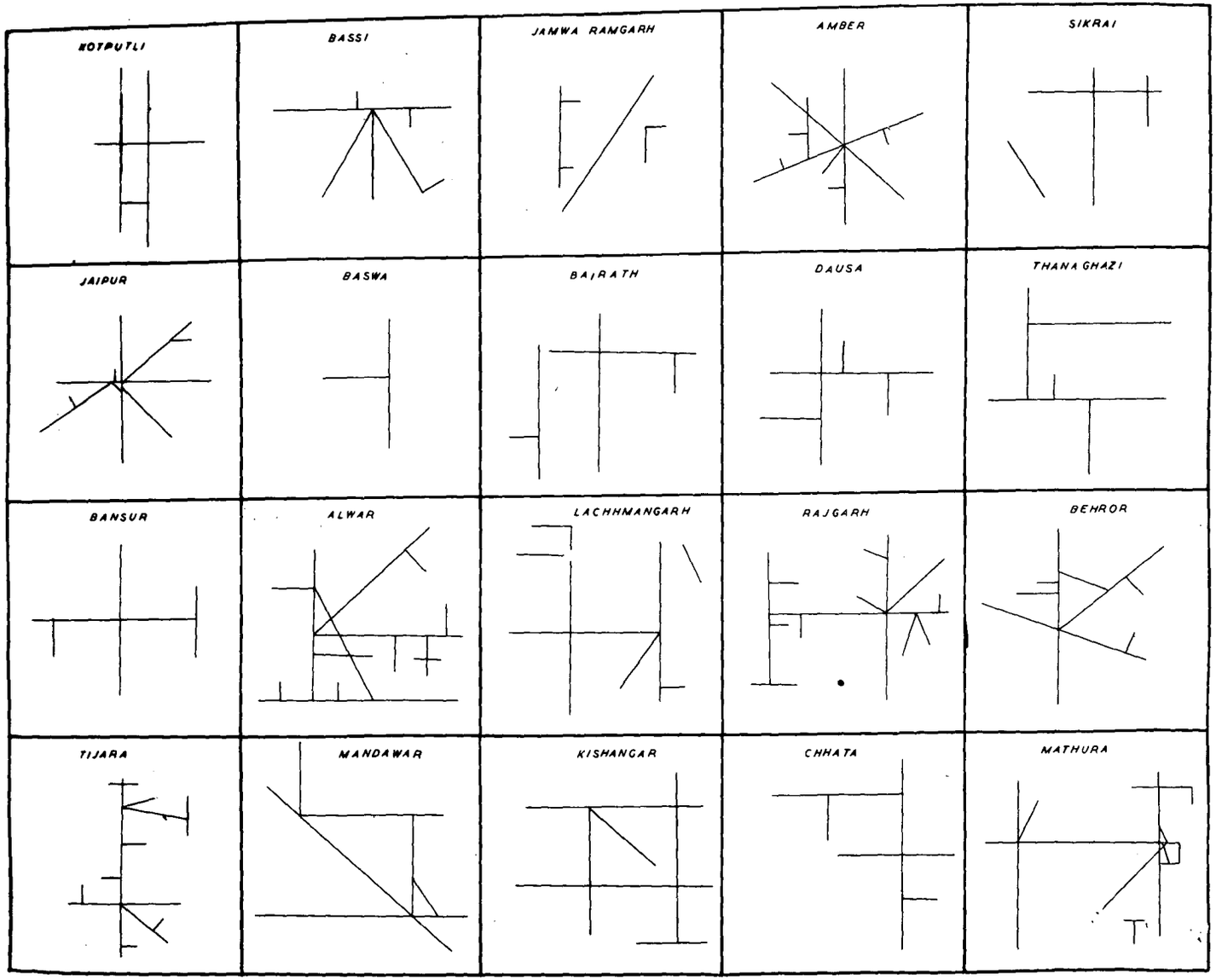


FIG-5

The simplified road network also gives some interesting pictures. In many tehsils the road system is a broken one, which shows the absolute backwardness of the network. In such a network which does not link each other roads, the chances of interaction are least hence may be considered as poor network. The road network in Agra, Rewari, Delhi seems to be very much radial type from the maps. This indicates the importance of focal point from where all these roads are radiating. Generally, the roads are concentrated towards the tehsil headquarters with few exceptions. In all, the six tehsils of Haryana have very much complicated road network. Except Alwar and Bharatpur, all the tehsils of Bharatpur, Alwar and S. Madhopur district have very few roads. Road network of Tijara shows that there are good number of roads which are linked to the main roads but they don't contribute much to the structural efficiency of the network system. Thistype of system is not supposed to be good one because here the degree of inter-connectivity is least. The network systems which have maximum number of triangles, quartangle, squares or any type of such shapes contribute much to the total network structure in the region. It is because these types of roads connections make the circuits which lead to maximum interaction. Delhi, Ballabgarh and Gurgaon are very good examples of this fact.

Levels of network development

The composite index showing the transport network development has the values ranging from 0.43 in Kaman to 2.44 in Ballabgarh. By quartiling the composite score the whole region is divided into four classes. The most developed tehsils, (which

Table No. 7

Levels of Road Network Development

S.No.	Name of Tehsil	Indices of Development of Road Network						Indices of Development of Road Network — Scale Free								
		M	r	⅄	Dn	β	n	Theta	H	Q	M	r	⅄	Dn	β	n	Theta	H	Q	Total	(C.I) Divided by indicators
1.	Gurgaon	5	.61	.02	.41	72.15	2.99	2.16	20	72.81	3.93	1.809	4.0909	2.252	2.556	1.010	2.66	1.18	1.64	21.13	2.34
2.	Ballabgarh	4	.79	.02	.41	77.55	2.05	1.60	12	71.65	3.14	2.34	4.545	2.52	2.747	1.473	1.972	1.96	1.61	22.03	2.44
3.	Palwal	0	.51	0	.26	53.80	2.32	1.24	14	67.61	0	1.51	0	1.428	1.906	1.302	1.528	1.68	1.52	10.88	1.20
4.	F. Jhirka	3	.69	.013	.33	72.98	2.38	1.74	22	74.60	2.36	2.046	3.1135	1.813	2.585	1.261	2.145	1.07	1.68	18.07	2.00
5.	Rewari	9	.27	.014	.25	47.59	3.14	1.49	24	61.05	7.08	.8007	3,2954	1.373	1.686	1.319	1.837	1.00	1.38	19.77	2.19
6.	Mathura	1	.21	.004	.16	22.93	3.49	.80	22	-	.78	.6227	.9090	.879	.812	.865	.986	1.07	-	6.89	.86
7.	Chhata	0	.19	0	.08	15.62	3.58	.56	16	-	0	.563	0	.4394	.555	1.025	.690	1.47	-	4.64	0.58
8.	Agra	1	.51	.007	.32	40.99	2.37	.96	22	-	.78	1.5124	1.5909	1.758	1.452	1.274	1.183	1.07	-	10.62	1.32
9.	Kiraoli	2	.27	.011	.17	24.86	2.68	.66	14	-	1.57	.8007	2.500	.934	.880	1.130	.813	1.68	-	10.31	1.28
10.	Delhi	9	.22	.016	.07	38.23	3.59	1.37	22	66.07	7.08	.6524	3.636	.384	1.354	.841	1.689	1.07	1.49	18.20	2.02
11.	Kaman	0	.10	0	.08	13.84	2.86	.39	34	-	0	.2965	0	.439	.4903	1.056	.480	.69	-	3.45	.43
12.	Nagar	0	.29	0	.20	17.5	4.57	.80	30	-	0	.860	0	1.098	.620	1.597	.986	.78	-	5.94	.74
13.	Deeg	0	.25	0	.07	14.15	3.56	.51	28	-	0	.741	0	.384	.5013	.848	.628	.84	-	3.94	.49
14.	Nadbai	0	.38	0	.16	23.14	2.58	.59	12	-	0	1.127	0	.879	.820	1.170	.727	3.3	-	8.02	1.00
15.	Bharatpur	1	1.10	.002	.17	18.33	2.6	.47	22	-	.78	3.262	.4545	.934	.649	1.161	.579	1.09	-	8.91	1.11
16.	Weir	1	.40	.008	.19	31.41	2.39	.75	13	-	.78	1.86	1.8181	1.043	1.113	1.264	.924	1.78	-	9.91	1.23
17.	Toda Bhim	0	.23	0	.11	16.66	2.66	.44	40	29.36	0	.682	0	.604	.590	1.135	.542	.59	.66	4.80	.53
18.	Mahwa	0	.28	0	.12	20.94	1.86	.38	13	31.60	0	.830	0	.659	.742	1.632	.468	1.78	.71	6.82	.75
19.	Kotputli	0	.36	0	.07	20.86	2.70	.56	9	23.24	0	1.067	0	.384	.739	1.118	.690	2.56	.52	7.08	.78
20.	Bairath	0	.25	0	.09	16.00	4.89	.78	18	38.21	0	.741	0	.494	.567	.617	.961	1.31	.86	5.55	.61
21.	Amber	0	.59	0	.12	34.48	3.72	1.28	40	38.24	0	1.749	0	.659	1.222	.812	1.578	.59	.86	7.47	.83
22.	Jaipur	1	.53	.019	.17	26.47	3.79	1.004	28	34.57	.78	1.572	4.318	.934	.938	.797	1.237	.84	.78	7.90	1.35
23.	Jamwa Ramgarh	0	.08	0	.05	10.20	3.84	.39	20	30.70	0	.237	0	.274	.361	1.013	.483	1.18	.69	4.24	.47
24.	Baswa	0	.123	0	.05	9.87	2.00	.198	16	21.63	0	.365	0	.274	.350	.527	.244	1.47	.49	4.38	.48
25.	Bassi	0	.17	0	.13	15.67	2.93	.46	16	33.81	0	.504	0	.714	.555	.773	.567	1.47	.76	5.34	.59
26.	Dausa	0	.70	0	.09	10.30	3.78	.39	20	25.13	0	.504	0	.494	.365	.799	.480	1.18	.57	4.39	.48
27.	Sikrai	0	.27	0	.11	18.51	3.38	.44	12	44.72	0	.8007	0	.604	.656	1.269	.542	1.96	1.01	6.80	.75
28.	Behror	1	.33	.007	.15	27.87	2.51	.70	12	44.69	.78	.9785	1.5909	.824	.987	1.203	.863	1.96	1.01	10.19	1.13
29.	Mandawar	1	.34	.010	.17	23.74	2.96	.70	24	35.70	.78	1.008	2.2727	.934	.841	1.179	.863	.98	.80	9.65	1.07
30.	Kishangarh	0	.18	0	.15	19.33	2.80	.54	33	29.20	0	.5338	0	.824	.685	1.078	.665	.71	.66	5.15	.57
31.	Tijara	0	.28	0	.17	23.66	3.36	.79	34	39.93	0	.8303	0	.934	.838	.899	.974	.68	.90	6.05	.67
32.	Bansur	0	.26	0	.11	16.93	3.66	.61	21	35.48	0	.371	0	.604	.600	.825	.752	1.12	.80	6.25	.60
33.	Alwar	4	.095	.005	.13	19.56	2.88	.56	59	40.91	3.14	.2817	1.1363	.714	.693	1.048	.690	.39	.92	9.01	1.00
34.	Thanaghazi	0	.32	0	.09	21.37	3.53	.75	27	25.52	0	.9489	0	.494	.757	.855	.924	.88	.57	5.43	.60
35.	Rajgarh	0	.26	0	.12	28.57	2.18	.80	34	35.73	0	.771	0	.659	1.012	1.385	.986	.68	.80	6.29	.69
36.	Lachhmangarh	0	.09	0	.10	13.86	3.62	.50	48	39.28	0	.2669	0	.549	.491	.834	.616	.49	.88	4.13	.45
37.	Nuh	4	.48	.011	.42	64.41	2.60	1.67	23	70.19	3.14	1.4234	2.50	2.307	2.282	.736	2.67	1.03	1.58	17.66	1.96

comes in fourth quartile) from the point of view of transport network development, are the following:

Ballabgarh	2.44
Gurgaon	2.34
Rewari	2.19
Delhi	2.02
F. Jhirka	2.00
Nuh	1.96
Agra	1.32
Kiroli	1.28

All these highly developed tehshils are crossed by the national highway except F.Jhirka and Nuh. The tehsils which have appeared to be the most backward (which come in first quartile) regarding the network development are the following:

C.I. Values		C.I. Values	
Kaman	.43	Deeg	.49
Lachhmangarh	.45	Toda Bhim	.53
Jamwa Ramgarh	.47	Kishangarh	.57
Dausa	.48	Bassi	.59
Baswa	.48		

Map No. 6 indicates that there are distinct inter-regional variations in the levels of road network development. The north, north eastern and eastern parts of the region are making a distinct zone of developed transport network. There is another smaller zone of the tehsil of Weir, which also has high level of road

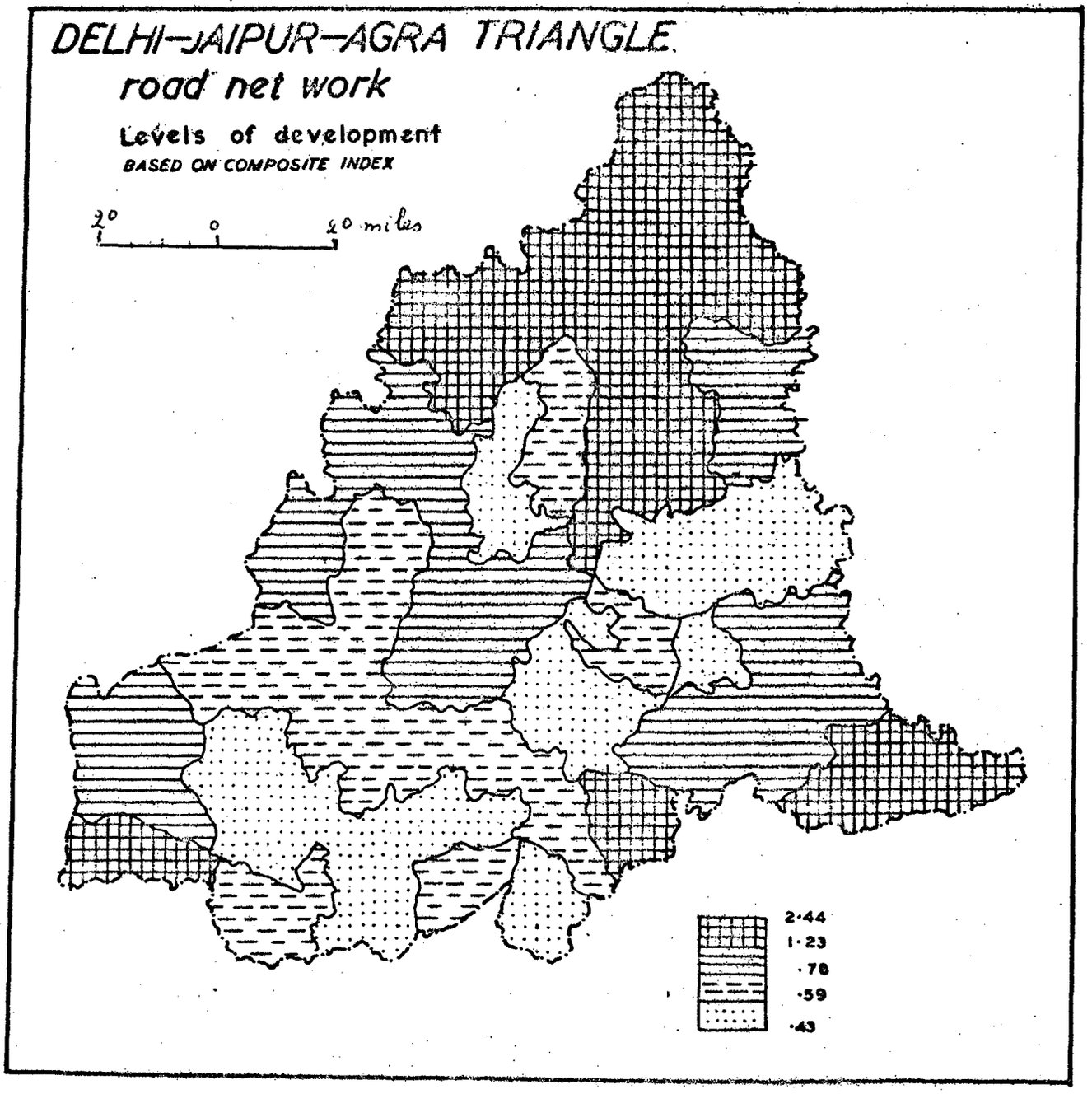

DELHI-JAIPUR-AGRA TRIANGLE.
road net work
Levels of development
BASED ON COMPOSITE INDEX
20 0 20 miles
2·44
1·23
·78
·59
·43

FIG 6

network. This smaller zone is surrounded from all three sides by lowest level of road network, moderately low level of network and lastly by moderately high level of road network.

It should be noted that most of the tehsils which have high level of road network, do occupy marginal positions and most of them are crossed by national highway. On the other hand, a big chunk of area in southwest (except Jaipur and Amber), and Tehsil of Tijara, Kishangarh, Lachhmangarh, Deeg, Kaman and Nagar (which are in the interior of the region)show the low level of road network development. Tehsils of Alwar, Jaipur, Bharatpur are the unique cases in the region. These tehsils have high level of road network development, but surrounded by the tehsils of low level of network development. For example, the value of composite index (which shows the level of road network development) for Alwar tehsil is 1.00 where as this value is only .45 for Lachhmangarh and .57 for Kishangarh. This abrupt variation in the levels of network development can be understood by the fact that these tehsils of high level of network development (which are surrounded by low level of road network development) are district headquarters. Being important from administrative point of view, these have more interactions, which resulted in high level of road network development. If we compare the levels of network development (Map No.6) and the actual road network (Map No.3a), some interesting conclusions emerge out. In the areas where the road network is complicated the levels of road network in terms of the value of composite index is also high.

For instance, Ballabgarh, Gurgaon, Nuh, Rewari, etc. tehsils in Haryana have complicated road network in the sense that the number of roads is comparatively very high, whose composite scores are also very high. This means that there is close relationship between the volume of roads and the composite scores of tehsils. However, there are certain exceptions to this feature, for instance Tijara tehsil. Thistehsil has no doubt several roads but their structure is such that most of the roads stretches are parallel to each other and are connected by few approach roads. In such tehsils roads do not make circuit as a result of which the interaction in the hinterland of that road remains poor.

CHAPTER III

REGIONAL TRANSPORT CONNECTIVITY

In this chapter the patterns of transport connectivity have been worked out within the region at two levels of areal analysis; first within the tehsil and secondly between the tehsils. By transport connectivity we mean the linkages of settlements by bus-transport. However, no reference has been made either to the frequency of transport or passenger movement by bus. It is presumed here that the bus linkages could give at least the connectivity-pattern, though not its intensity. The bus time-tables collected from Regional Transport Offices of Jaipur and Agra, Haryana Roadways Head Offices at Gurgaon and Narnaul, Scheduled Section of Delhi Transport Corporation at Delhi, provide the data base for the analysis carried out in this chapter.

The connectivity indices for within the tehsil and between the tehsils have been worked out on two basis: (1) Connectivity as the ratio of maximum possible connectivity of settlements along the road and (2) Connectivity as ratio to maximum possible connectivity of settlements in a tehsil. The first index has been calculated to see what is the level of connectivity of settlements which are already along the roads. For calculating connectivity on second basis the reason is that the connectivity of the settlements along the roads is not thefinal aim but ultimate objective is to see the level of connectivity in relation to total settlements in a tehsil.

There are 7448 settlements in the region out of which 1343 are along the roads. By the settlements along the roads we

we mean all those settlements which are within a distance of one furlong from the roads. Of the total settlements in the region, 18.03 % are along the roads.

The northern part of the region (including tehsils of Haryana and Delhi) and Agra in the east have highest proportion of settlements along the roads. Gurgaon and Ballabgarh are the tehsils where half of its total settlements are along the roads. This northern part of the region has very high road density. This is the category in which the proportion of settlements along the roads is above 20.

The tehsils of moderately high concentration of settlements along the roads are fragmented into three small sub-regions; Mathura in the southeast, Rajgarh in midsouth, Behror and Kotputli in west, form these sub-regions. Here the percentage of settlements ranges from 15 to 20.

The tehsils which have low concentration of settlements (10-15%) are highly fragmented and do not occupy a contiguous region. The tehsils which have lowest concentration of settlements along the roads make four sub-regions where the percentage is below 10. The biggest chunk of area of this category is located in southwest of the region.

The settlements concentration along the roads is below 15% in all those tehsils which lie over the rugged surface of Aravallis in south-western part of the region.

Intra-Tehsil Bus Connectivity:

Not all the villages within the tehsils are connected by buses. It is only those settlements which are along the roads that are connected through the buses acting as either transitory points or terminal points. This prompts one to investigate into the connectivity amongst the settlements which are along the roads. By connectivity, we mean the linkages of a settlement by bus with another settlement. Thus, if a settlement is linked with a large number of settlements by bus, it is said to have higher connectivity than a settlement which is linked with a few number of settlements. Thus the matrices have been prepared for all the settlements along the roads for every tehsil, where each linkage is given the value of one and from where a composite value for bus-connectivity has been calculated, thus giving the observed connectivity (c) of settlements along the roads. The observed connectivity is different from the optimum connectivity which is calculated as n(n-1) (where n stands for the total number of settlements), where every settlement would be connected with every other settlement. The ratio between the observed connectivity and the optimum connectivity would give us the connectivity index.

$$\text{Thus} \qquad CI = \frac{C}{n(n-1)}$$

Where CI stands for the index of connectivity

c stands for the observed connectivity

n stands for the total number of settlements within the tehsi

In the second instance the connectivity index (CI) has been calculated as the ratio of observed connectivity amongst the settlements along the roads (c) to optimum connectivity amongst such settlements where n1 stands for the number of settlements along the road.

I. Interpretation of Connectivity Index:

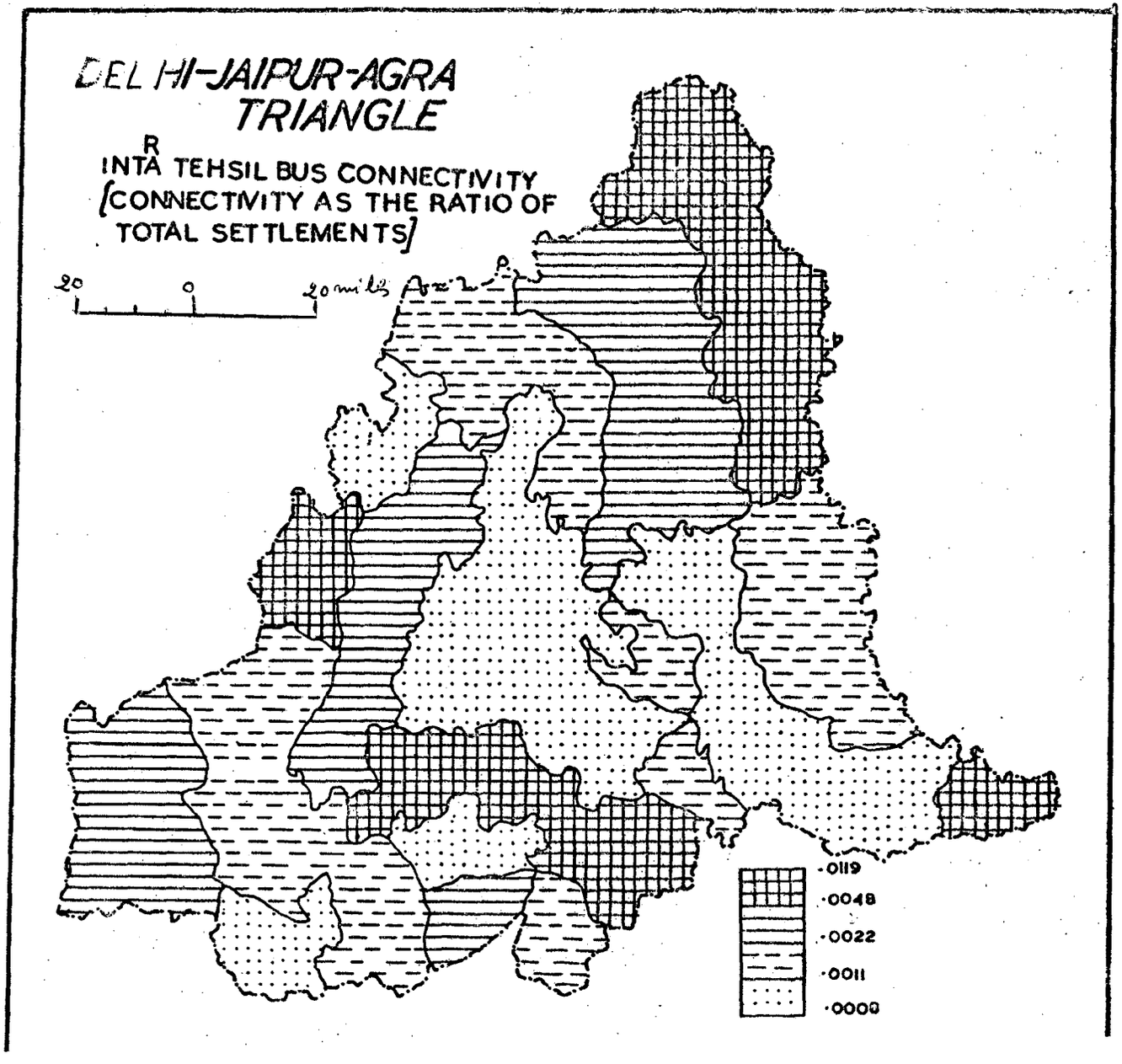
The values of the connectivity index ($CI = \frac{C}{n(n-1)}$ have been plotted in fig.7 based on quartiles to identify the regional pattern of distribution of its values. The following observations are made:

(i) High Connectivity Areas

The tehsils of high connectivity are Delhi, Mahwa, Kotputli, Agra, Weir, Rajgarh, Ballabgarh, Jaipur, Palwal and Behror, where the index values range from .0050 to .0119. These tehsils do not form a contiguous region, but are in four fragmented subregions in the north, south-south-east, south and west. The northern sub region has the maximum area covering the tehsils of Palwal, Ballabgarh and Delhi. While the eastern sub-region consists of Agra tehsil alone.

(ii) Medium Connectivity Areas

The tehsils of Gurgaon, Nuh, F. Jhirka, Jaipur, Thangazi, Sikrai, Mandawar, Bansur, and Amber have moderately high level of connectivity. The index values in these tehsils


DELHI-JAIPUR-AGRA
TRIANGLE
R
INTRA TEHSIL BUS CONNECTIVITY
(CONNECTIVITY AS THE RATIO OF
TOTAL SETTLEMENTS)
20
0
20 miles
·0119
·0048
·0022
·0011
·0000

range from .0025 to .0048. This region too is fragmented into four sub-regions. The northern sub-region consists of the tehsils of Gurgaon, Nuh and F. Jhirka. The sub-region in the southwest consists of Jaipur and Amber; in the west only Bansur and Thangazi and in south Sikrai. As seen from fig.7, most of the tehsils of moderately high connectivity are located in the western part of the region extending from northeast to southwest.

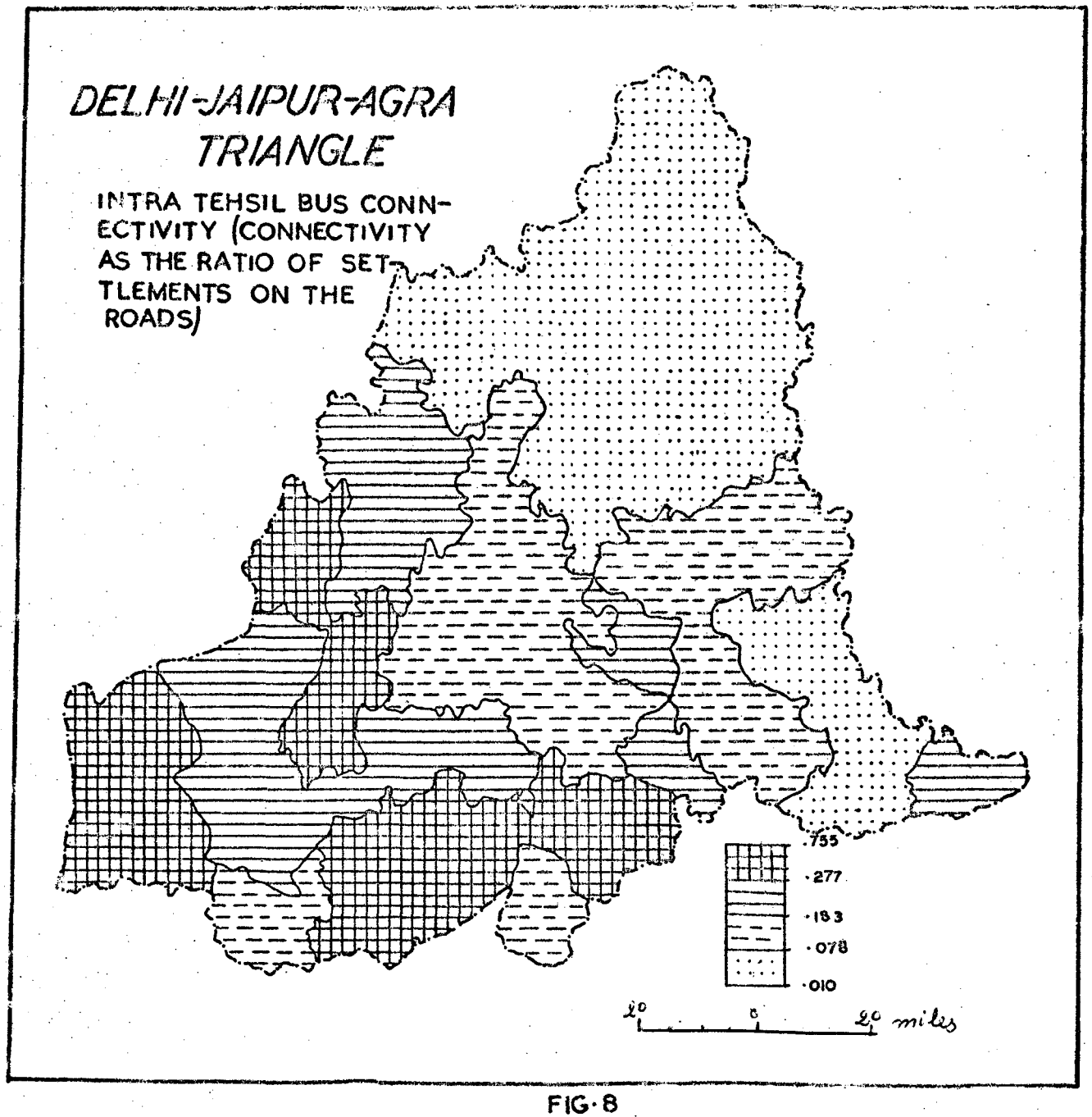
(iii) Low Connectivity Areas

The tehsils of low connectivity are Bairath, Nagar, Chhata, Dausa, Nadbai, Tijara, Mathura, Toda-Bhim, J. Ramgarh and Rewari where the connectivity index values range from .0011 to 0022. The sub-regions of this category are scattered and occupy marginal positions in the region. The southwestern sub-region which covers tehsils of Bairath, J. Ramgarh, and Dausa occupies the maximum area. Rewari and Tijara form a sub-region in the northwest, Chhata and Mathura form a sub-region in the east.

(iv) Lowest Connectivity Areas

The tehsils which fall under the lowest level of connectivity are Kishangarh, Bassi, Baswa, Lachhmangarh, Alwar, Deeg, Kaman, Bharatpur and Kiraoli where connectivity index values range from .0008 to .0011. Leaving apart Behror, Baswa and Sikrai, the tehsils of this level of connectivity make almost a contiguous belt extending from northwest to southeast.

II. Connectivity index for settlements along the roads $\left[C1 = \frac{e}{n_1 (n_1-1)} \right]$ has been illustrated in fig.8 on the


DELHI-JAIPUR-AGRA
TRIANGLE
INTRA TEHSIL BUS CONN-
ECTIVITY (CONNECTIVITY
AS THE RATIO OF SET-
TLEMENTS ON THE
ROADS)
·755
·277
·183
·078
·010
20 0 20 miles

FIG·8

basis of quartile method. The regional patterns emerging out of the illustration have been discussed in the following paragraphs:

(i) High Connectivity Areas

The tehsils where the CI values are high are Sikrai, Jaipur, Mahwa, Kotputli, Thangazi, Weir, Baswa, Amber and Dausa. The index values range from .294 to .755. All these tehsils of high intra-tehsil connectivity are located in the southwest of the region.

(ii) Medium Connectivity Areas

The tehsils of medium connectivity are Nadbai, Bansur, Bairath, J. Ramgarh, Behror, Mandawar, Rajgarh, Agra and Nagar where index values range from .189 to .277. Most of the area which falls under this level of connectivity is located in the west and southwestern part of the region.

(iii) Low Connectivity Areas

The tehsils of moderately low intra-tehsil bus connectivity are Chhata, Kaman, Bassi, Kishangarh, Lachhmangarh, Deeg, Alwar, Toda Bhim and Bharatpur with connectivity values ranging from .092 to .183. The zone of this connectivity level lies roughly in the middle of the region, is almost contiguous zone only interrupted by Nagar tehsil.

(iv) Lowest Connectivity Areas

The whole of northern part of the region and Koraoli and Mathura tehsils on the southeast have low intra tehsil bus connectivity. The connectivity index values range from .010 to .078.

In brief, one can identify well marked intra-regional variations in connectivity index from fig. 8. In the north and east is the region of lowest level of connectivity followed by the zone of moderately low connectivity in the middle portion of the region. This zone has a tendency to extend towards the mideast. The third zone of medium connectivity stretches in the mid-western position. In the west and south west of the region, is observed the highest level of connectivity. Thus the connectivity index shows a tendency for declinefrom southwest to north and northeast.

If we put all the four categories only in two groups of high and low connectivity, the region is clearly divided into two parts i.e. northeast and southwest. Northeastern region has low level of connectivity and southwestern half high level of connectivity. The point which should be noted is that the zone of high connectivity has rugged topography, while the zone of low level of connectivity is characterized by level surfaced topography.

The comparison of figure numbers 7 and 8 reflects some contrasting situation in northern part of the region. Here the intra tehsil bus connectivity is high if it is calculated in relation to total settlements. The situation becomes just reverse if it is calculated as ratio to maximum possible connectivity of settlements along the roads. This sharp contrasting

phenomenon can be explained if we see the mechanism of two different formulae used for determining the levels of connectivity. The tehsils of Haryana have high index of cyclamatic number and alpha, which have increased the chances of high interactions of settlements among themselves. Because of high level of road network development the intra tehsil bus connectivity (as ratio to maximum possible bus connectivity of settlements in a tehsil) is also high. But the level of connectivity comes lowest in this region if the connectivity is analysed as ratio to maximum possible intra tehsil busconnectivity of settlements along the roads. The reason is that there are large number of settlements along the roads and on all the roads the buses are not plying. As a result of that the denominator value (maximum possible connectivity of settlements along the roads) becomes very high which has resulted in the low level of connectivity. On the other hand there may be some tehsils where there are very few roads but all are served by the buses. Here the connectivity may become very high since the denominator value is low (because of few settlements along the roads). Thus the intra tehsil bus connectivity of northern region could be explained.

Inter Tehsil Bus Connectivity

Inter-tehsil bus connectivity has been calculated by the summation of direct connections of villages of one tehsil to the villages of another tehsil. Afterwards, its ratio has been calculated first to (1) to maximum possible connections in two given tehsils $[(V_1 X V_2)$, V_1 stands for number of vertices in a

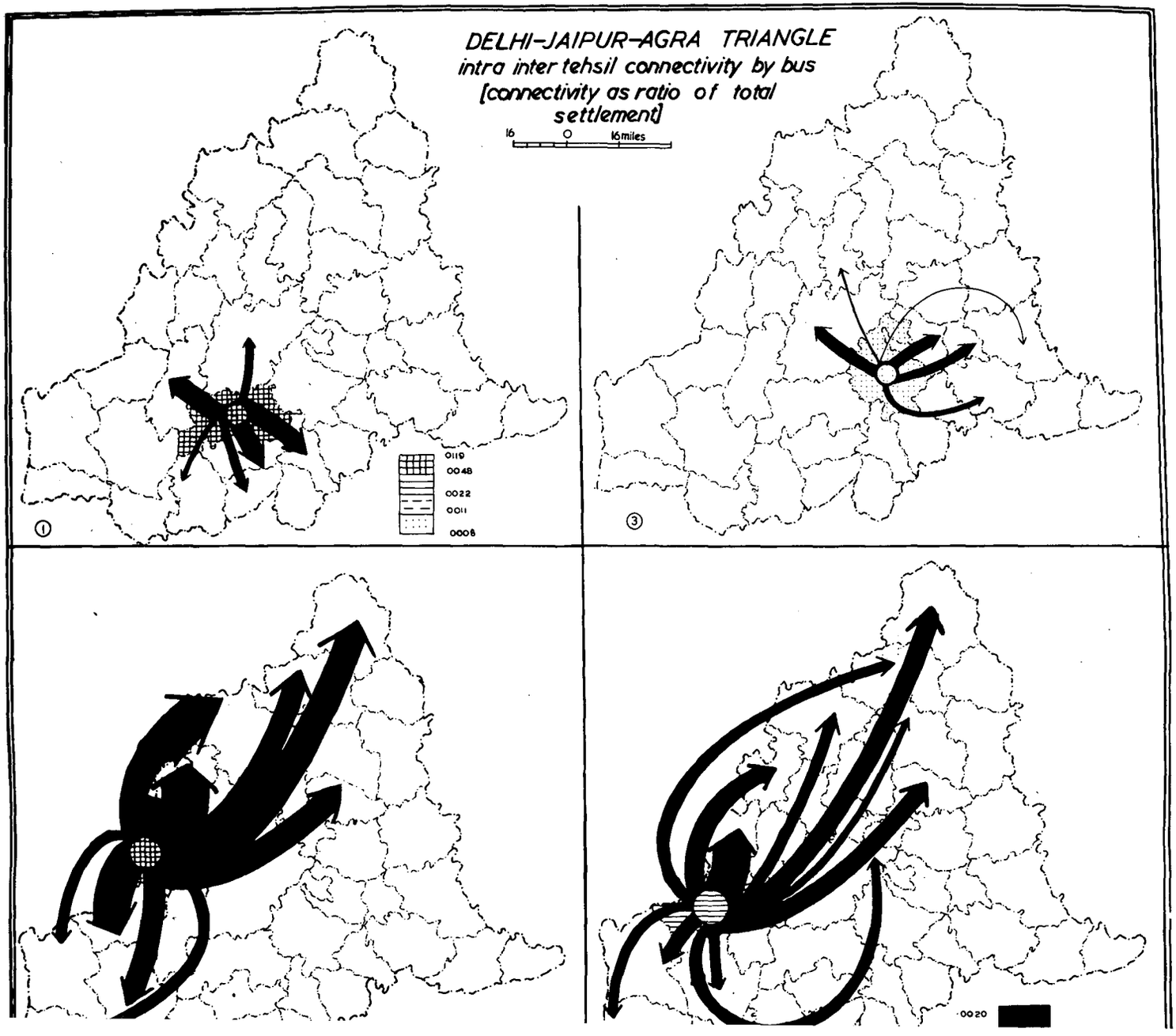
tehsil, V_2 stands for number of vertices in another tehsil] secondly to the maximum possible connections of the settlements along the roads ($v_1 x v_2$), v_1 stands for number of settlements along the roads in one tehsil, v_2 stands for number of settlements along the roads in another tehsil). Thus by taking the ratio the inter-tehsil bus connectivity values become comparable in the analysis. The degree (values) of inter-tehsil bus connectivity of one tehsil with others has been shown in the flow maps (Fig. Nos. 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21).

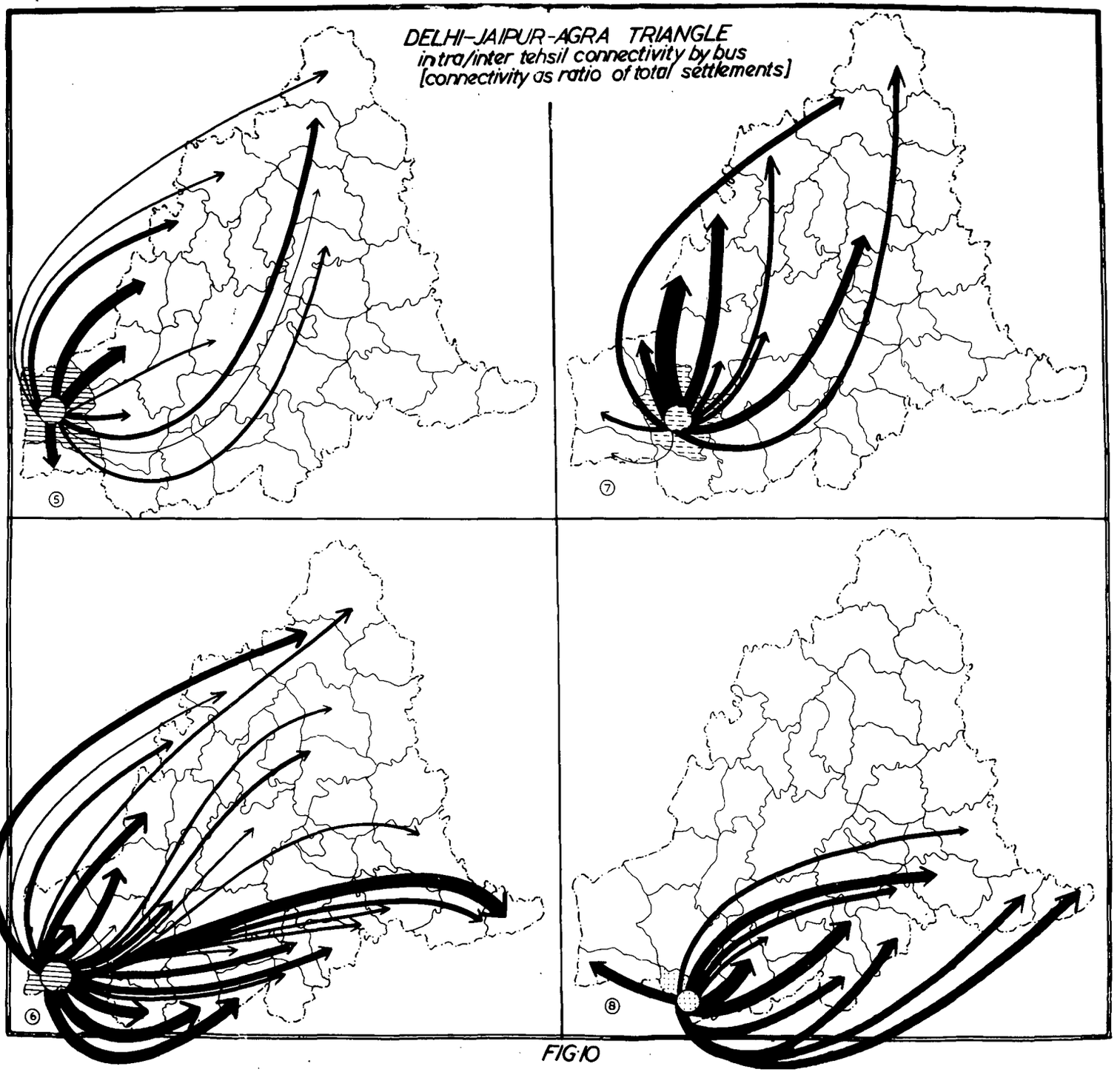
A. Inter-Tehsil Bus Connectivity (Connectivity as the ratio of maximum possible connectivity of settlements):

The average inter-tehsil bus connectivity based on total number of settlements is lowest for Tijara (.0007) and highest (.0065) for Gurgaon, as noted from off diagonal columns of the matrix 8. The following patterns of inter-tehsil bus connectivity emerge from the study of flow maps. (Fig. 9, 10, 11, 12, 13, 14, 15, 16, 17).

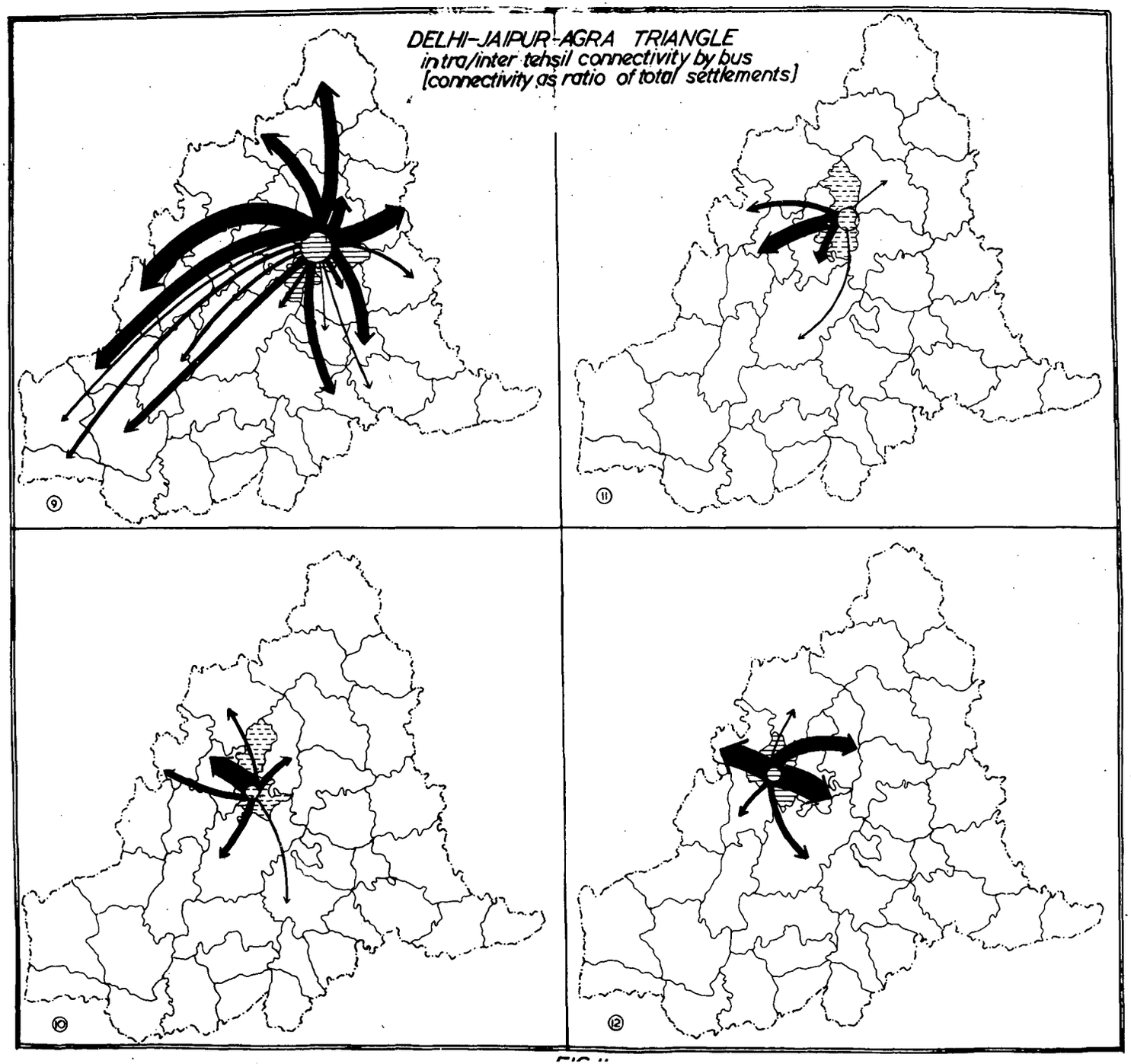
1. Tehsils of high connectivity and high distance range

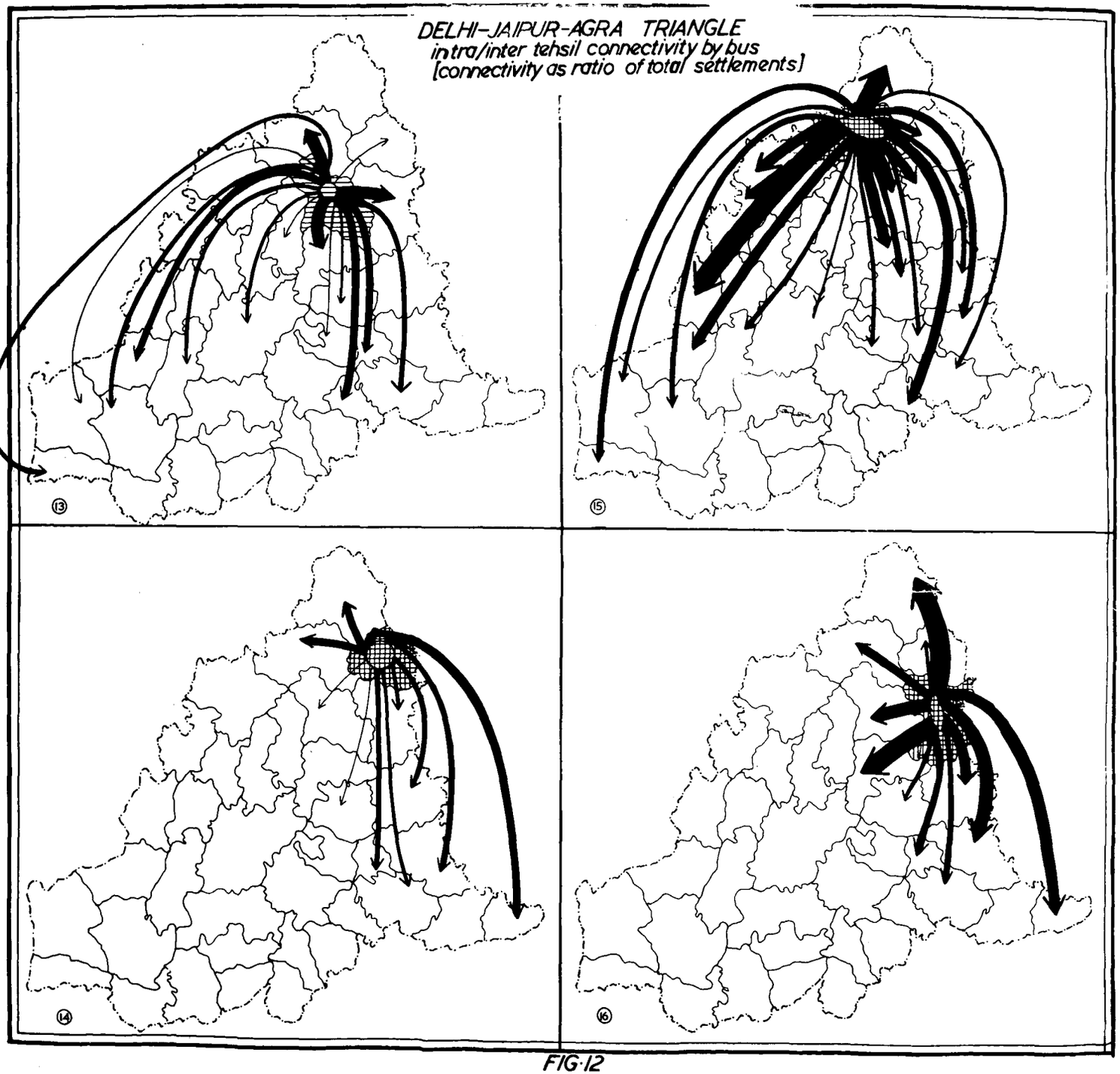
Tehsils with a high degree of connectivity and covering larger range of distance are Behror, Dausa, Sikrai, Mahwa, Toda-Bhim, F. Jhirka, Gurgaon, Palwal, Bharatpur, Kotputli, Bairath, Jawwa Ramgarh, Jaipur, Bassi, Mathura, Chhata, Weir, Agra and Kiraoli. These make almost a contiguous circular zone, covering maximum area along the national highways. The settlements of Jaipur tehsil have maximum interconnection with 131 settlements in


DELHI-JAIPUR-AGRA TRIANGLE
intra inter tehsil connectivity by bus
[connectivity as ratio of total settlement]
16 0 16 miles
0119
0048
0022
0011
0008
①
③
0020

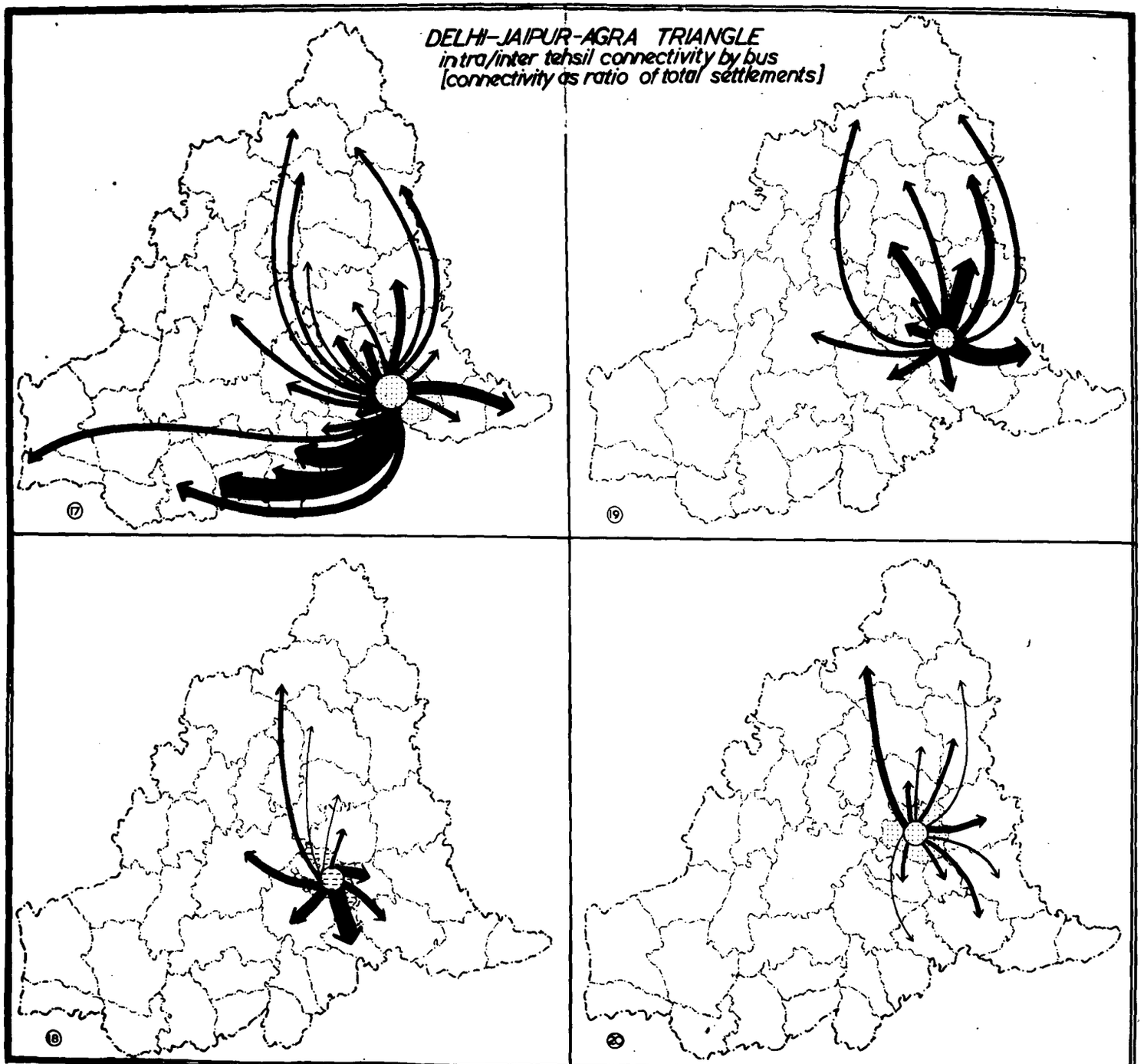

DELHI–JAIPUR–AGRA TRIANGLE
intra/inter tehsil connectivity by bus
[connectivity as ratio of total settlements]
⑤
⑦
⑥
⑧

FIG·10


DELHI-JAIPUR-AGRA TRIANGLE
intra/inter tehsil connectivity by bus
[connectivity as ratio of total settlements]
⑨
⑪
⑩
⑫


DELHI-JAIPUR-AGRA TRIANGLE
intra/inter tehsil connectivity by bus
[connectivity as ratio of total settlements]
13
15
14
16

FIG·12


DELHI-JAIPUR-AGRA TRIANGLE
intra/inter tehsil connectivity by bus
[connectivity as ratio of total settlements]
⑰
⑲
⑱
⑳

FIG·13

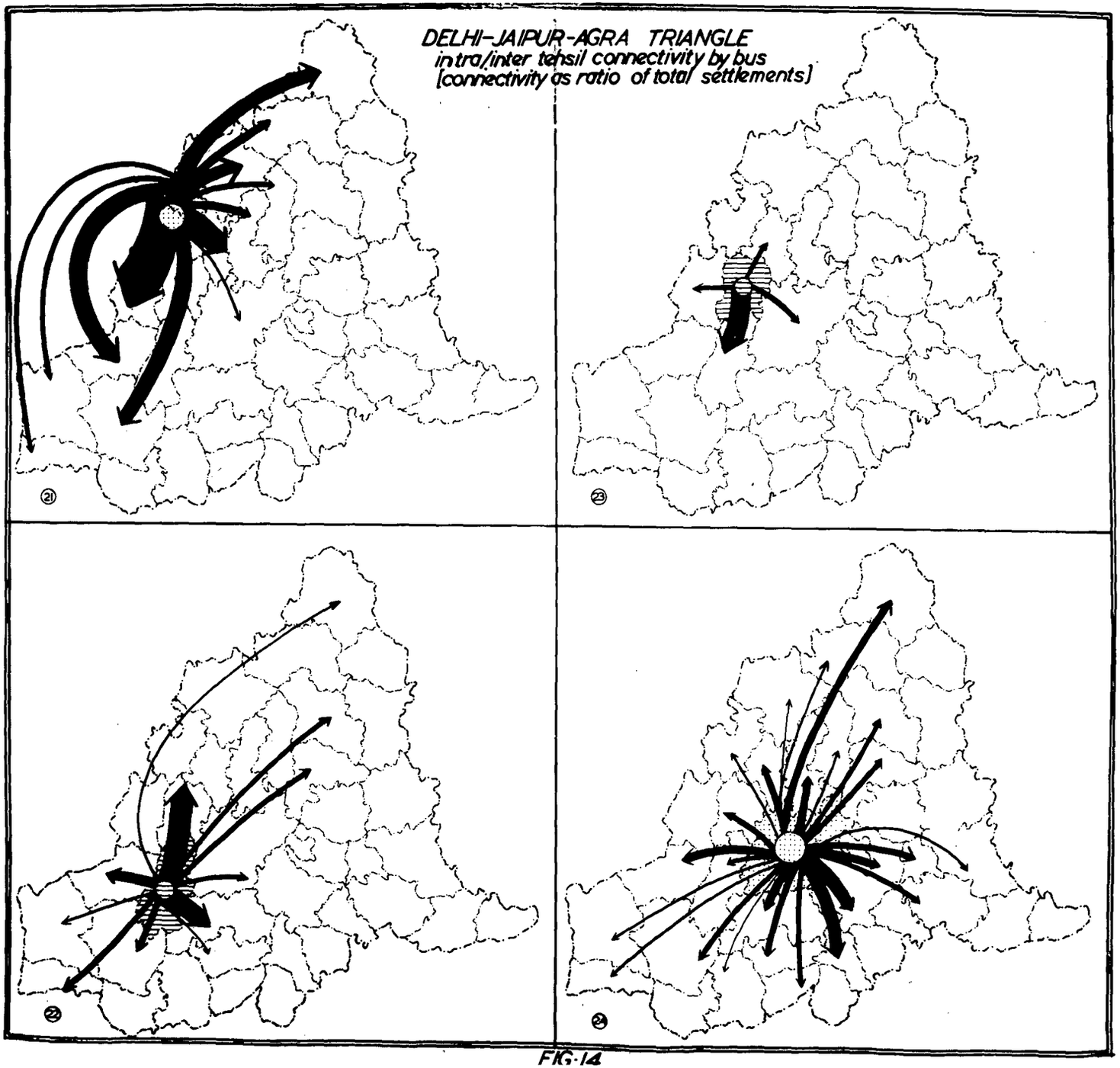
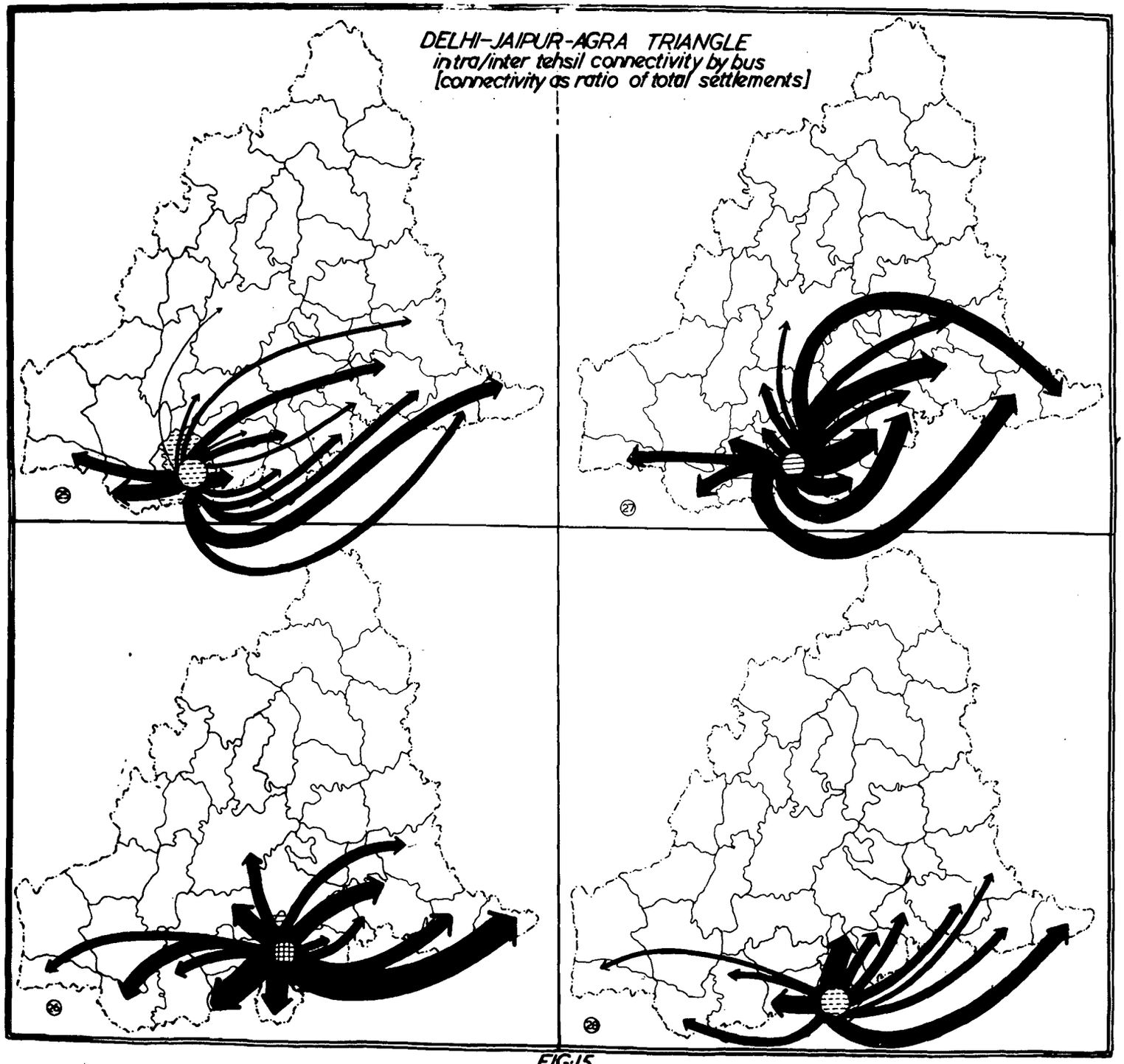

DELHI-JAIPUR-AGRA TRIANGLE
intra/inter tehsil connectivity by bus
[connectivity as ratio of total settlements]
21
23
22
24

FIG-14


DELHI-JAIPUR-AGRA TRIANGLE
intra/inter tehsil connectivity by bus
[connectivity as ratio of total settlements]

FIG·15

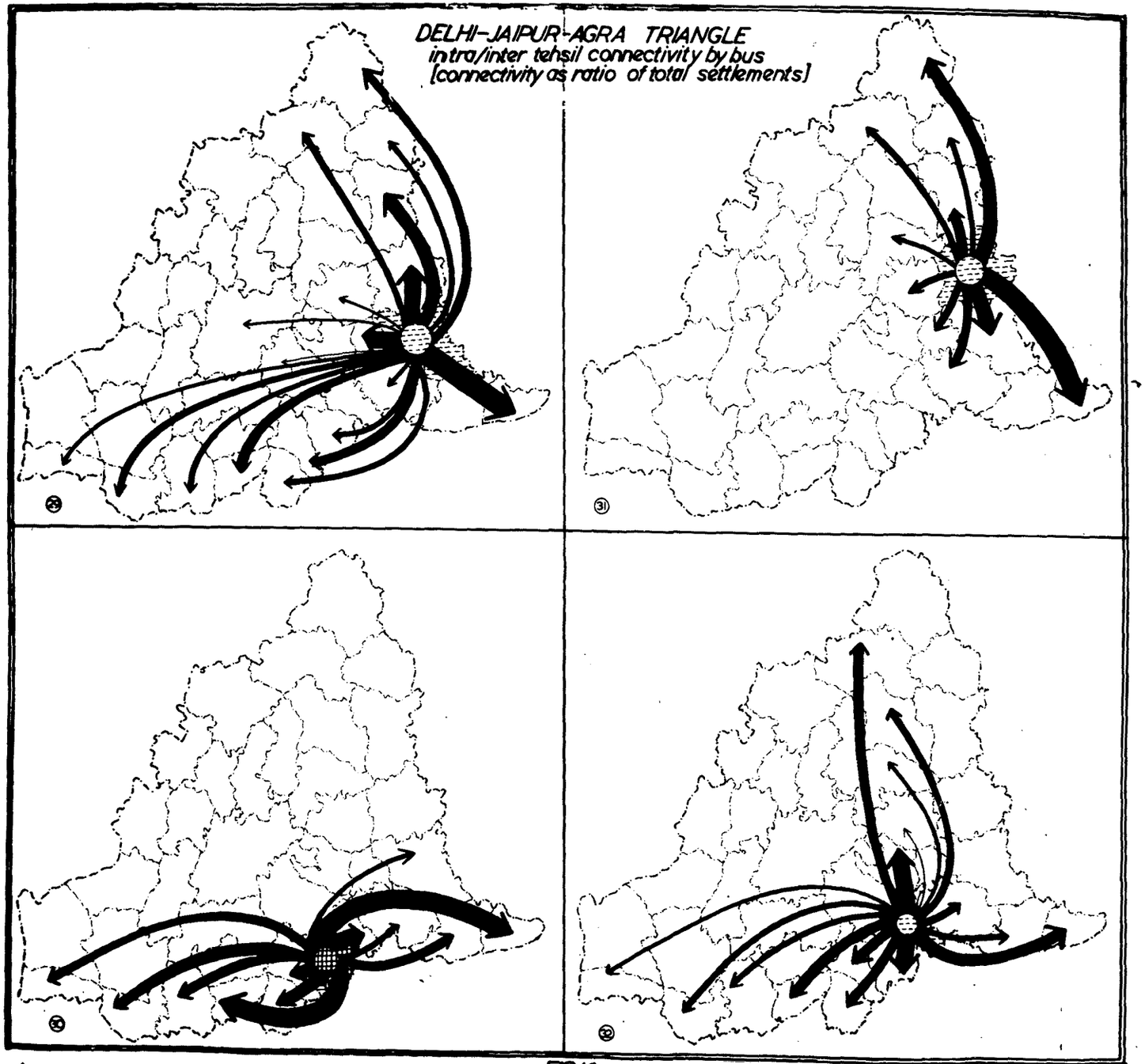
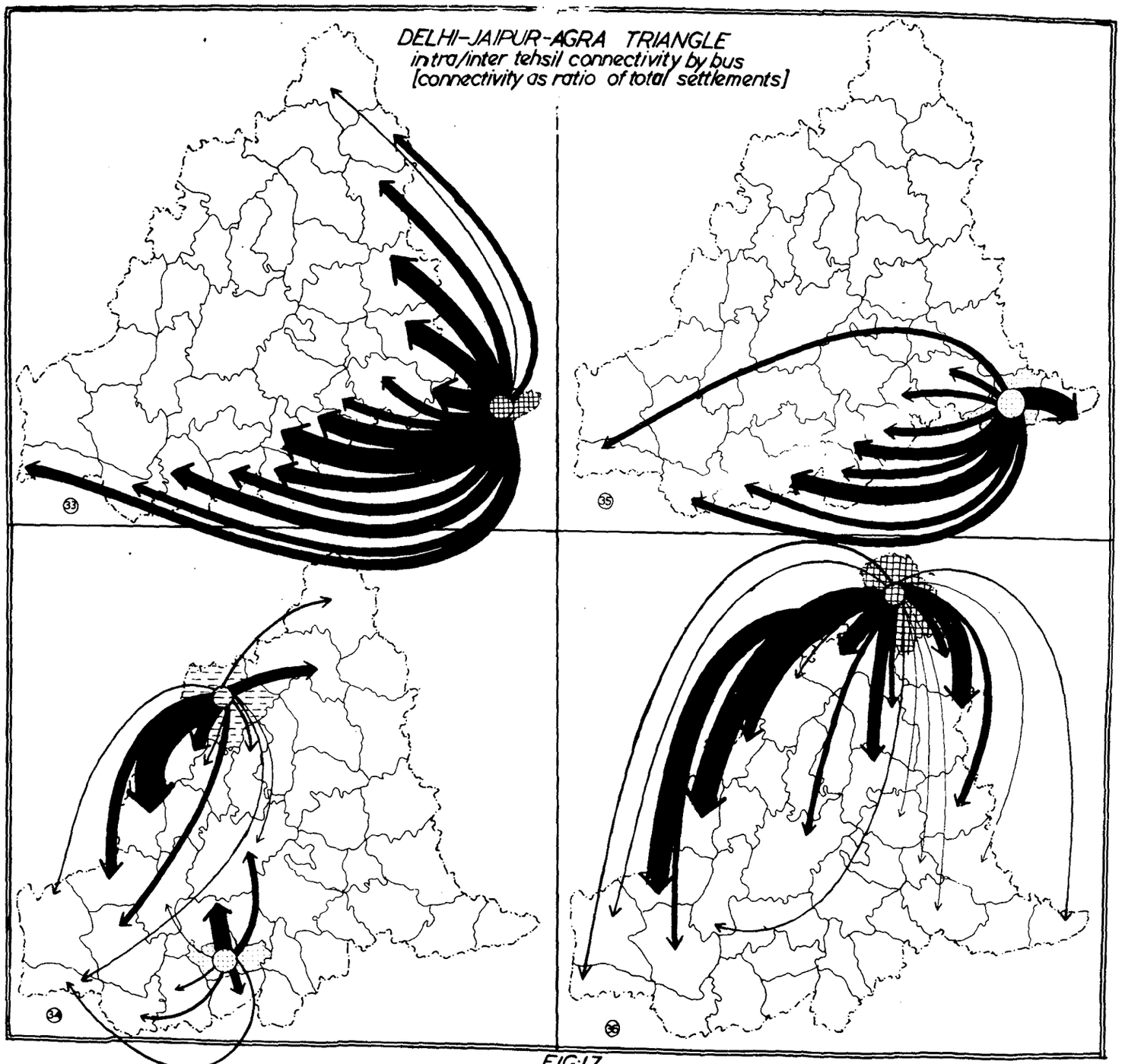
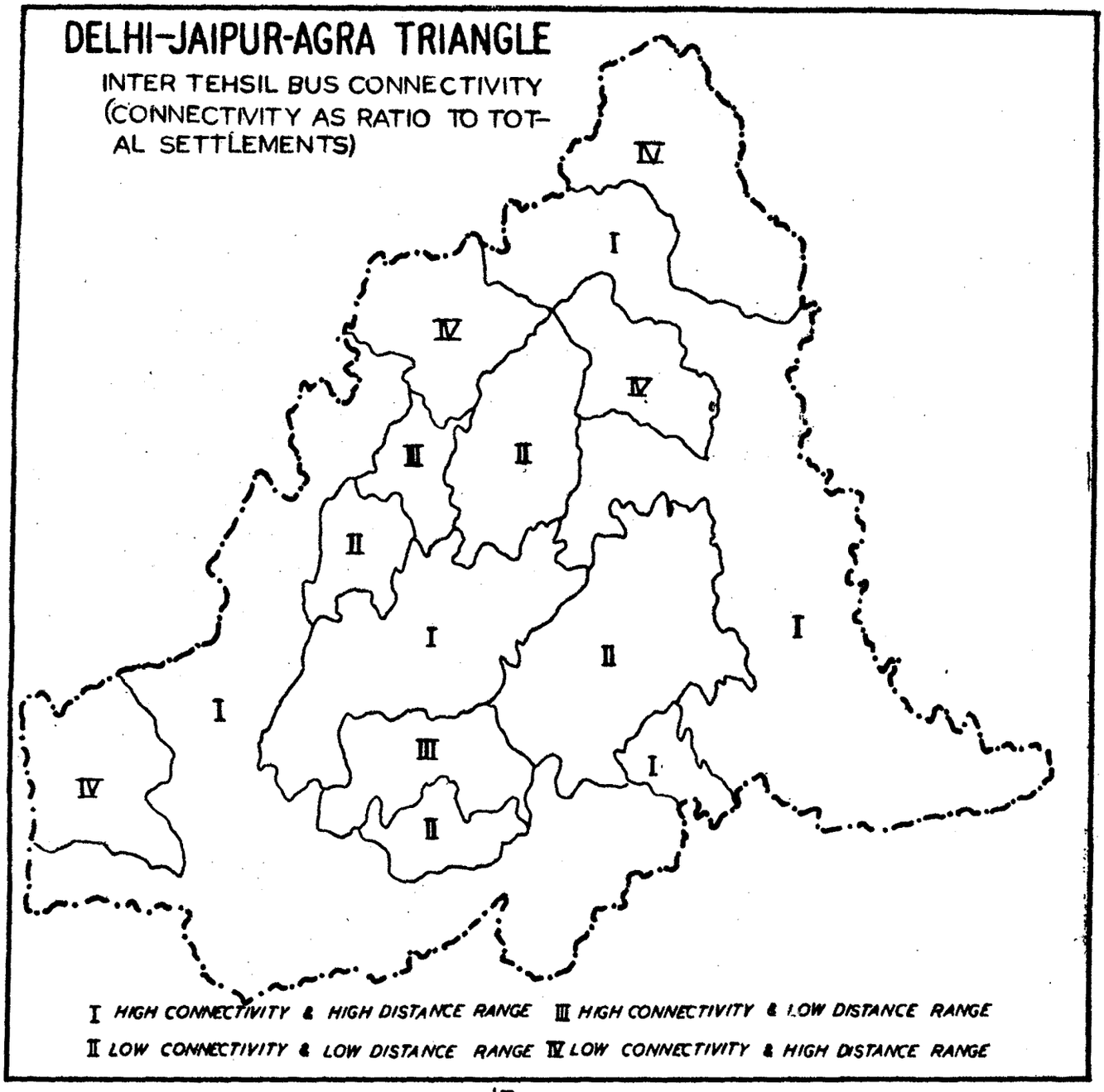

DELHI-JAIPUR-AGRA TRIANGLE
intra/inter tehsil connectivity by bus
[connectivity as ratio of total settlements]

FIG-16


DELHI-JAIPUR-AGRA TRIANGLE
intra/inter tehsil connectivity by bus
[connectivity as ratio of total settlements]
33
35
34
36

FIG·17


DELHI-JAIPUR-AGRA TRIANGLE
INTER TEHSIL BUS CONNECTIVITY
(CONNECTIVITY AS RATIO TO TOT-
AL SETTLEMENTS)
I HIGH CONNECTIVITY & HIGH DISTANCE RANGE
III HIGH CONNECTIVITY & LOW DISTANCE RANGE
II LOW CONNECTIVITY & LOW DISTANCE RANGE
IV LOW CONNECTIVITY & HIGH DISTANCE RANGE

17a

the region and settlements of Kotputli have minimum connections only with 21 villages. The maximum distance of interaction is 284 between kms between the villages of the tehsils of Jaipur and Gurgaon.

2. Low connectivity and low distance range

The tehsils with low connectivity and low distance range are Bansur, Tijara, Kishangarh, Deeg, Nagar, Kaman, Lachhmangarh and Baswa. They do not form a contiguous region, yet all the sub-zones lay in the middle of the region. The settlements of Deeg have maximum direct connections with 53 settlements and minimum connections are of the settlements of Bansur with 14 settlements of the region. The maximum interaction extends up to a distance of 152 kms between the villages of tehsils Deeg and Delhi.

3. High connectivity and low distance range

Only two tehsils, viz., Mandawar and Rajgarh fall in this category. They form two discontinuous areas (Fig.17a). The settlements of Rajgarh interact with 47 settlements and settlements of Mandawar with 30 settlements in the region. None of the villages of these tehsils have interactions beyond a distance of 50 kms.

4. Low connectivity and high distance range

The tehsils of Thanagazi, Alwar, Nuh, Ballabgarh, Amber, Nadbai, Rewari and Delhi fall in this group. These tehsils form several sub-regions on account of their areal discontiguity. However, a large part of the area with these characteristics is

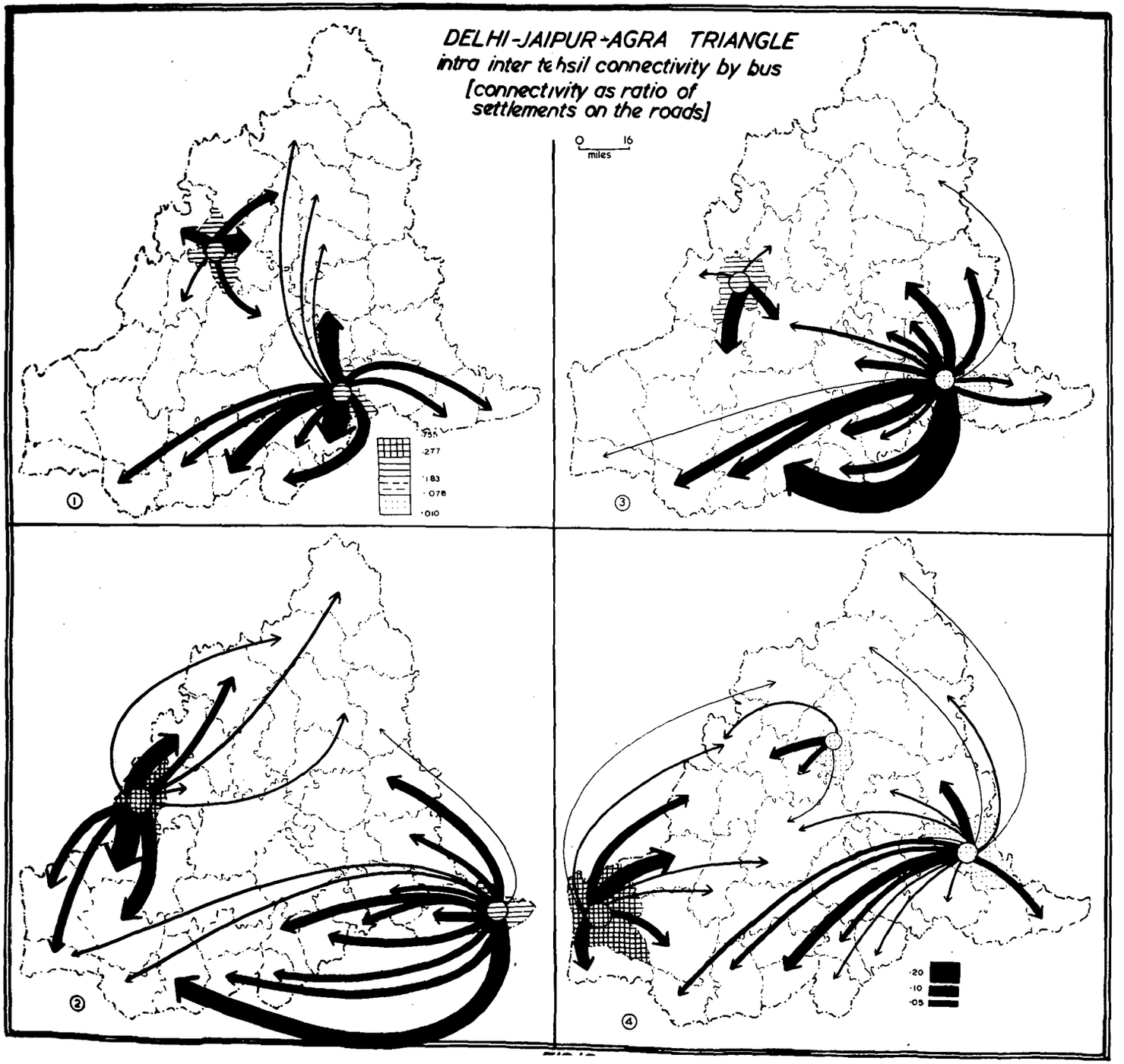
located in the western half of the region. In this group the settlements of Delhi have maximum direct connections with 141 villages of the region and settlements of Ballabgarh tehsil interact only with 35 villages (minimum in the group). The maximum distance of interaction is 300 kms.

B. Inter-Tehsil Bus Connectivity (Connectivity as the ratio to maximum possible connectivity of settlements along the roads)

Matrix 9 shows the inter-tehsil bus connectivity as ratio to maximum possible connectivity of settlements along the roads. Here the average inter-tehsil bus connectivity values range from .00130 for Ballabgarh to .06777 for Sikrai. The study of flow maps (Fig.Nos.18, 19, 20, 21) brings out the following four types of regions of bus connectivity on the basis of said indicator:

1. High Connectivity and High Distance Range

The tehsils which have high connectivity and high distance range are Nadbai, Bharatpur, Agra, Bassi, Dausa, Kiraoli, Sikrai, Mahwa, and Weir. They make a continuous zone along the southern border of the region (fig.21a). All the tehsils through which the Jaipur-Agra national highway passes, except the tehsils of Jaipur and Toda Bhim, fall in this group. The villages of Bharatpur are connected with maximum number of villages 112 in the region and villages of Bassi are connected only with 48 villages (minimum in the region). Here the interaction of villages extends up to a maximum distance of


DELHI-JAIPUR-AGRA TRIANGLE
intra inter tehsil connectivity by bus
[connectivity as ratio of settlements on the roads]
0 16
miles
·355
·277
·183
·078
·010
①
②
③
④
·20
·10
·05

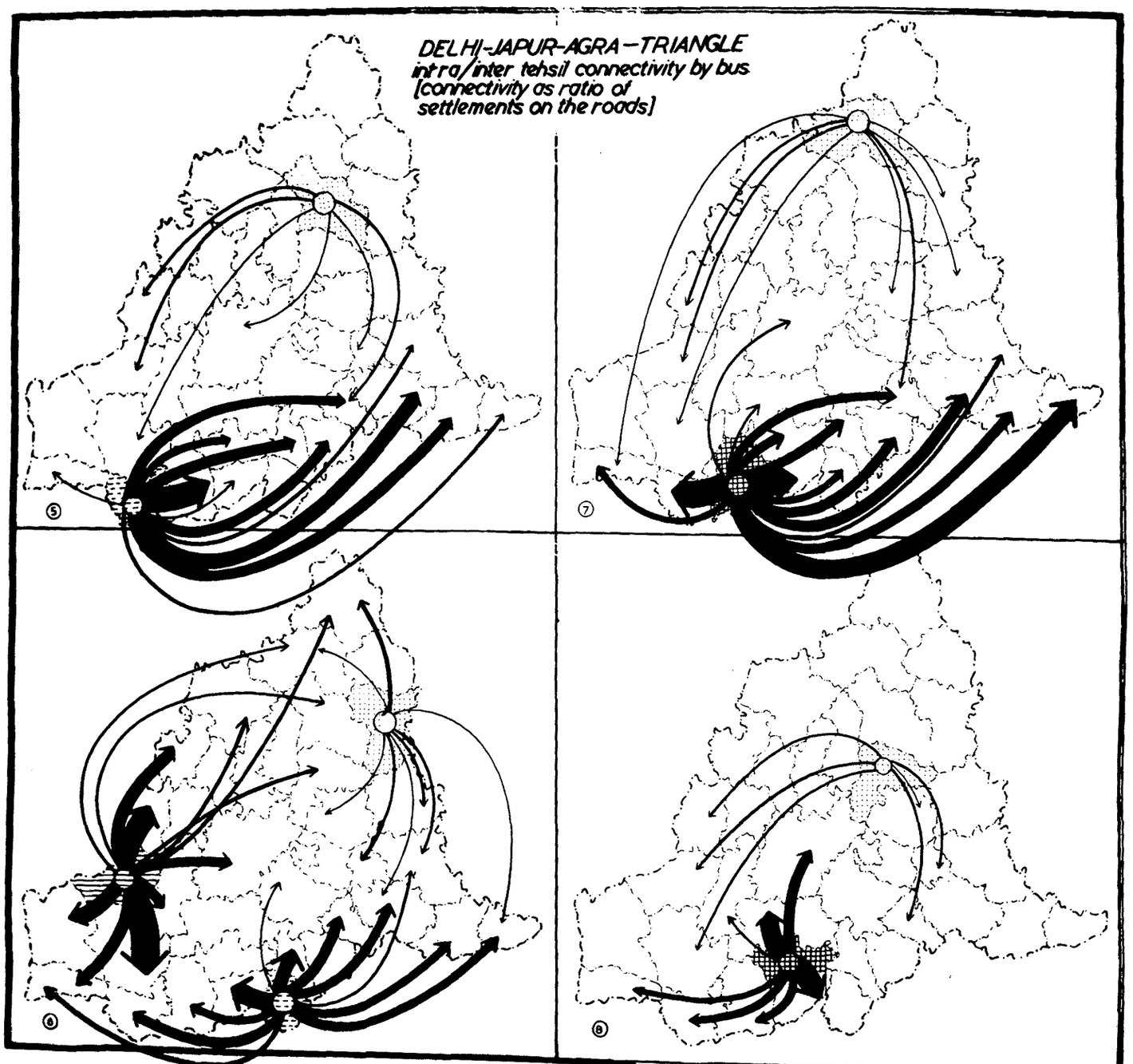

DELHI-JAPUR-AGRA-TRIANGLE
intra/inter tehsil connectivity by bus
[connectivity as ratio of
settlements on the roads]
⑤
⑦
⑥
⑧

FIG-19

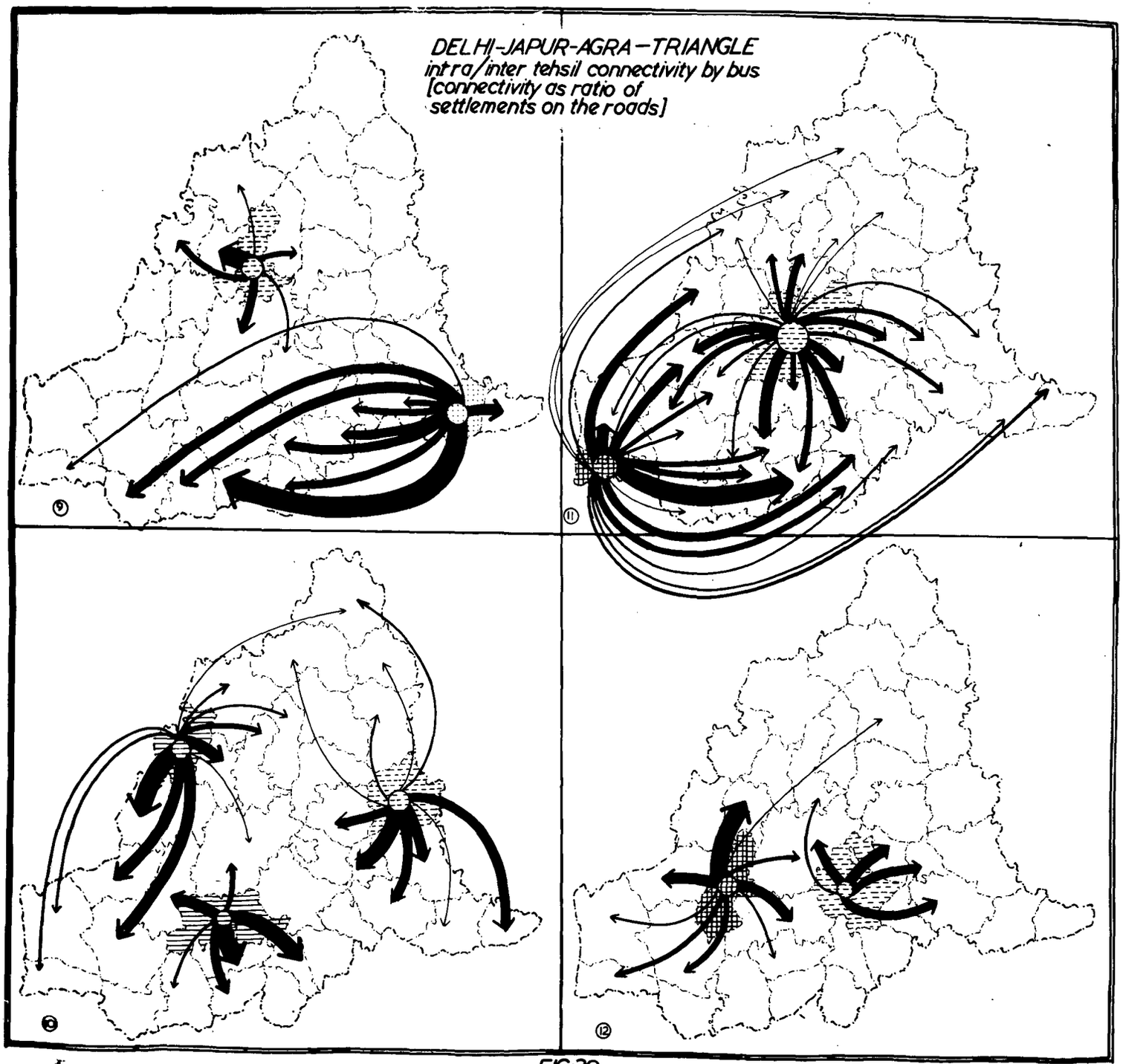

DELHI-JAPUR-AGRA-TRIANGLE
intra/inter tehsil connectivity by bus
[connectivity as ratio of
settlements on the roads]
⑨
⑪
⑧
⑫

FIG 20

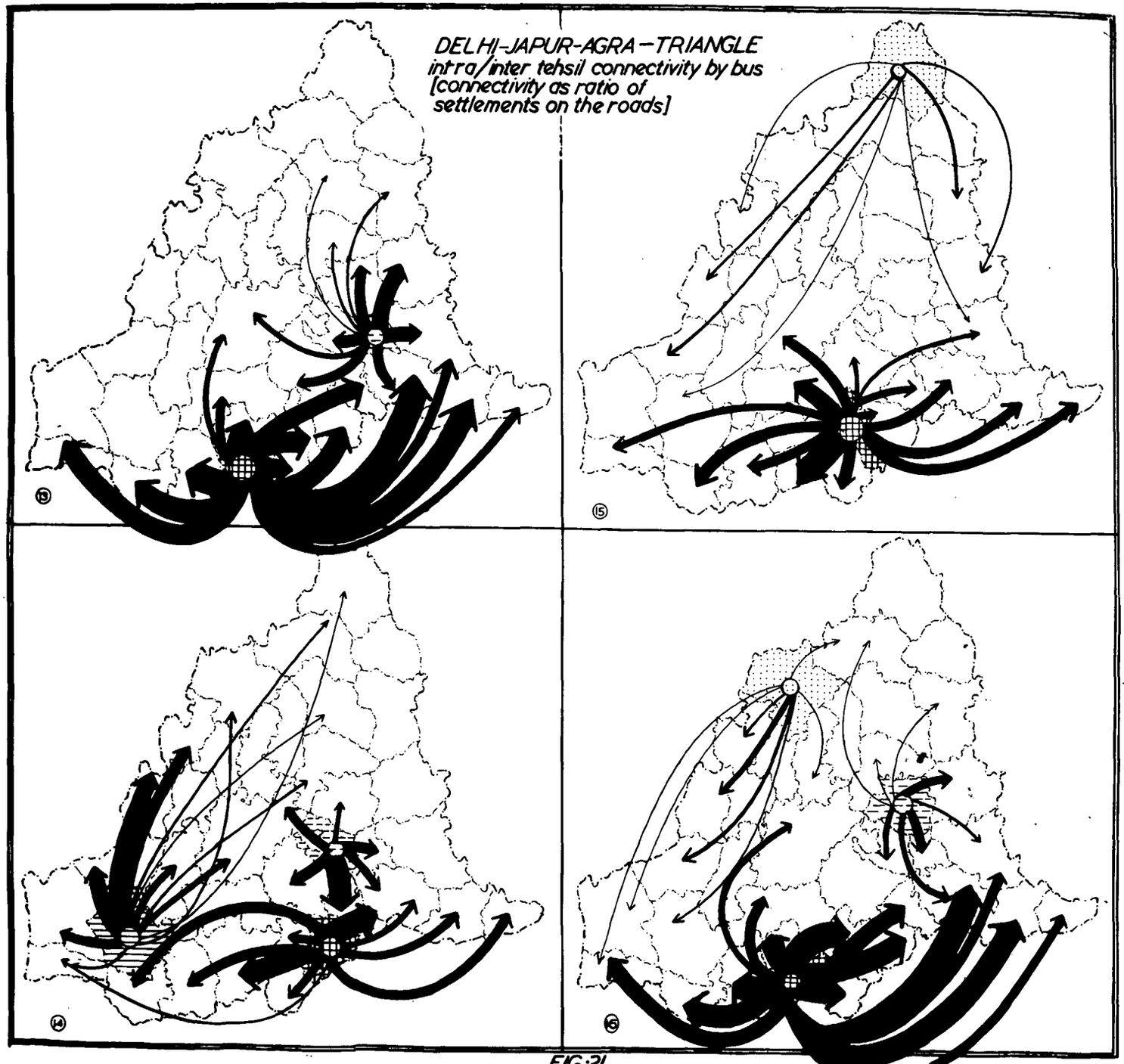
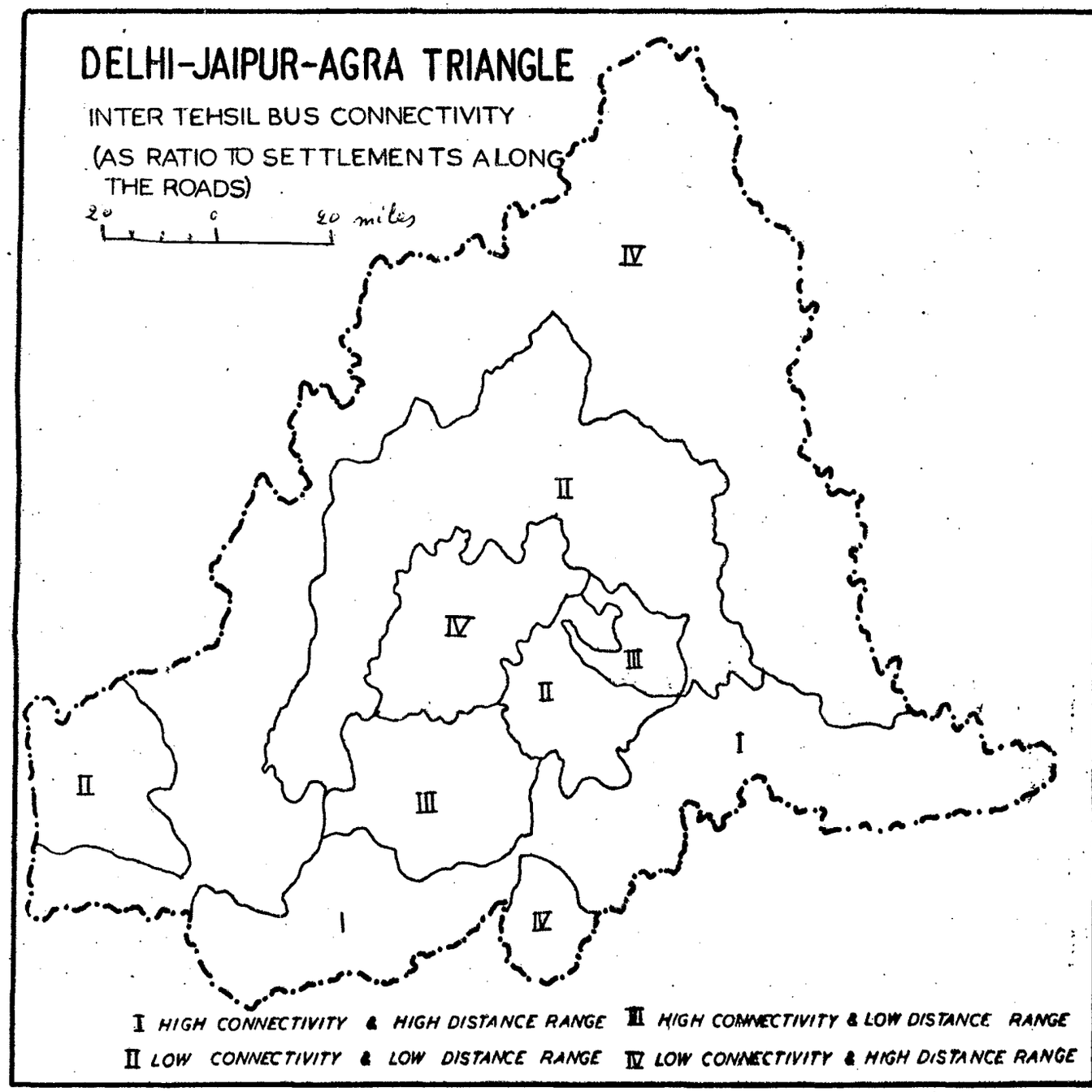

DELHI-JAPUR-AGRA – TRIANGLE
intra/inter tehsil connectivity by bus
[connectivity as ratio of
settlements on the roads]
⑬
⑮
⑭
⑯

FIG 21


DELHI-JAIPUR-AGRA TRIANGLE
INTER TEHSIL BUS CONNECTIVITY
(AS RATIO TO SETTLEMENTS ALONG THE ROADS)
20 0 20 miles
I HIGH CONNECTIVITY & HIGH DISTANCE RANGE
II LOW CONNECTIVITY & LOW DISTANCE RANGE
III HIGH CONNECTIVITY & LOW DISTANCE RANGE
IV LOW CONNECTIVITY & HIGH DISTANCE RANGE

21a

approximately 238 kms (between Sikrai and Agra). The main reason of long distance interactions is the national highway, which links the villages with each other for much longer distances.

2. Low Connectivity and Low Distance Range

The tehsils of Mandawar, Bansur, Amber, Tijara, F. Jhirka, Kishangarh, Thanagazi, Lachhmangarh, Deeg and Kaman fall in this category. These tehsils make two sub-regions. The smaller sub-region is in the west which includes only Amber tehsil is connected with 67 villages (maximum) of the region and settlements of Bansur are connected with 14villages, minimum in the region. The maximum interactions extend approximately up to a distance of 230 kms. This is the exceptional case. Most of the connections are below 100 kms.

3. High Connectivity and Low Distance Range

This pattern is shown by Baswa, Rajgarh and Nagar tehsils. These also make two small sub-regions located in mid south of the region. The settlements of Nagar tehsil are connected with 52 villages which is maximum in this group and Baswa with only 39 settlements (minimum in the region). The interconnections of the settlements of these tehsils are up to very limited distance. The maximum distance covered between the villages of Baswa to Jaipur is about 60 kms.

4. Low Connectivity and High Distance Range

This pattern is shown by the tehsils of Kotputli, Mathura, Nuh, Gurgaon, Bairath, Palwal, Toda Bhim, Jaipur, Alwar, Behror,

Chhata, Delhi, Jamwa Ramgarh and Rewari. The sub regions formed by these tehsils, occupy maximum area of our region. Except Alwar (which occupies middle position) and Toda Bhim (located in extremely south) all other tehsils make a contiguous zone which appear like an inverted V, extending over Delhi-Jaipur and Delhi-Agra national high ways. The villages of Delhi are connected with maximum number of villages (141) and villages of Kotputli are connected with mimimum number of villages (21) in the region. The settlements of the tehsils of this group have interactions up to a mazimum distance of 320 kms. The following salient features emerge from the study of inter-tehsil bus connectivity:

1. The tehsils which are traversed by the national highway have high distance range. This can be explained by the fact that the national highway tends to link the settlements of far off distances. The tehsils, which have interior location in Delhi-Jaipur-Agra triangle tend to have restricted distance range.

2. All connections, which reflect the high distance range are gravitated towards Agra, Delhi and Jaipur, i.e., indicating their tendency to be closely linked with the national highways and larger urban centres.

3. Generally, the tehsils of one national highway do not have interactions with the tehsils of another national highway.

4. Pattern shown by Alwar tehsil is unique. The tehsil shows a radial pattern and its interactions extend in all the

directions. It has its connections with all the three national highways (Fig.No.14, 20).

5. The tehsils which have high connectivity and low distance range are rather few in number and they are located mostly in the middle of the region.

6. Most of the tehsils in south along Jaipur-Agra national highway do have high connectivity and high distance range on both the basis. The reason is that there is low proportion of settlements along the roads but all these are directly interconnected to each other.

Table No. 8

Intra/inter Tehsil Bus Connectivity (Connectivity as the ratio of Total Settlements)

o.	Name of the Tehsil	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
	Nuh	.0028	.0011	.0012	.0001	.0011	.0001					.0003	.0003				.0006	.0001	.0003	.0003																		
	Gurgaon		.0048	.0009	.0007	.0011				.0009		.0002	.0004			.0021	.0010	.0003	.0006	.0007							.0003	.0005	.0001	.0002		.0006						
	Palwal			.0056	.0003	.0019																					.0003	.0004	.0003	.0006		.0009	.0005	.0005			.0011	.0005
	Ballabgarh				.0050																						.0005	.0008		.0003			.0011				.0018
	F. Jhirka					.0026						.0004	.0004			.0020	.0015	.0003	.0008	.0004							.0003	.0004		.0001		.0008	.0004	.0004	.0006	.0002		.0013
	Tijara						.0013	.0006	.0014	.0004		.0002															.0002	.0011	.0001	.0004				.0003				.0006
	Kishangarh							.0011	.0023	.0007		.0007			.0002																							.0013
	Mandawar								.0035	.0023	.0003	.0005																										
	Behror									.0005		.0002				.0047	.0016	.0004	.0012	.0004																	.0003	
	Bansur										.0032	.0005	.0021			.0003																					.0002	
	Alwar											.0009	.0003	.0007	.0010		.0008	.0002	.0004	.0002																	.0013	.0012
	Thanagazi												.0047	.0018			.0009	.0002	.0005	.0006																		
	Rajgarh													.0053								.0001	.0006	.0004	.0012		.0004	.0005	.0007									
	Lachhmangarh														.0009							.0003	.0001	.0009	.0018												.0001	.0005
	Kotputli															.0097	.0036	.0009	.0019	.0009																		.0002
	Bairath																.0022	.0013	.0010	.0009							.0006	.0008	.0010									
	Amber																	.0025	.0004	.0009												.0001						
	J. Ramgarh																		.0013	.0001																		
	Jaipur																			.0050	.0009	.0011	.0002	.0011	.0007	.0004	.0006									.0029	.0026
	Bassi																				.0011	.0015	.0003	.0012	.0013	.0008	.0009										.0018
	Dausa																					.0016	.0002	.0014	.0009	.0005	.0008									.0002	.0002
	Baswa																						.0010	.0008							.0006	.0003	.0003		.0012	.0005	.0002	.0005
	Sikrai																							.0037	.0027	.0016	.0020				.0009	.0005	.0005		.0006	.0008		.0003
	Malwa																								.0027	.0022	.0016				.0008	.0004	.0004		.0015	.0007		
	Toda Bhim																									.0013	.0009				.0019	.0010						
	Bharatpur																										.0008	.0008	.0007	.0003	.0013	.0008	.0008		.0017	.0013		
	Deeg																											.0009	.0011	.0003	.0011	.0009	.0005		.0027	.0013		
	Nagar																												.0019	.0003	.0005	.0006	.0003		.0017	.0008		
	Kaman																													.0008	.0017	.0017	.0016		.0010	.0005	.0010	.0001
	Weir																														.0017	.0001	.0002	.0004				.0001
	Nadbai																														.0053	.0017	.0004		.0019	.0009		.0001
	Mathura																															.0015			.0010	.0005		
	Chhata																																.0013	.0015	.0020			.0007
	Agra																																	.0018	.0020			.0014
	Kiraoli																																		.0078	.0020		.0002
	Rewari																																			.0008		
	Delhi																																				.0011	.0003
																																						.0119

Table No. 9

Intra/Inter tehsil bus connectivity (connectivity as the rates of settlements along the roads)

S.No.	Name of the Tehsil	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.	Nuh	.020	.0062	.0087	.0009	.0064	.0020					.0102	.0081			.0292	.0178	.0046	.0115	.0092							.0099	.0154	.0025	.0077		.0205							
2.	Gurgaon		.019	.0137	.0030	.0098										.0281	.0212	.0071	.0178	.0142							.0063	.0089	.0059	.0178		.0238	.0073	.0105			.0100		
3.	Palwal			.036	.0018	.0098																					.0137	.0213		.0142			.0184	.0263	.0142	.0049		.0400	
4.	Ballabgarh				.019																						.0061	.0096		.0032			.0059	.0084	.0064	.0016			
5.	F. Jhirka					.010	.0002																					.0222	.0027	.0138		.0222		.0063					
6.	Tijara						.061	.0426	.0759	.0184		.0092	.0073				.0320	.0041	.0208	.0083																	.0100		
7.	Kishangarh							.116	.1871	.0154		.0143			.0219																								
8.	Mandawar								.220	.1155	.0252	.0707																									.0100		
9.	Behror									.238		.0457				.0030																					.0200	.0100	
10.	Bansur										.274	.0158				.1645	.1098	.0285	.1000	.0285																		
11.	Alwar											.0476	.1680			.0225																						
12.	Thanagazi											.099	.0343			.0058	.0254	.0222	.0555	.0222		.0185	.1111	.0555	.0883		.0476	.0555	.0725				.0196					
13.	Raigarh												.404	.1000			.0904	.0235	.0588	.0470			.0294															
14.	Lachhmangarh													.207								.0277	.1875	.0800	.1458													
15.	Kotputli														.108										.0300		.0737	.0860	.1039									
16.	Bairath															.421	.2429	.0631	.1548	.0631													.0075					
17.	Amber																.256	.1461	.1346	.1000																	.0500	.0300
18.	J. Ramgarh																	.315	.0700	.1000																	.0300	.0300
19.	Jaipur																		.242	.0250																	.0100	
20.	Bassi																			.555	.0100	.0600	.0400	.1600	.0600	.0400	.0200				.0100					.0200	.0100	
21.	Dausa																				.163	.2407	.0666	.2000	.1000		.1190				.0925	.0740	.0392		.0300	.0200	.0100	
22.	Baswa																					.294	.0666	.2666	.0909	.0588	.1190				.0925	.0740	.0392		.0370	.0925		
23.	Sikrai																						.333	.2000											.1678	.0925		
24.	Mahwa																							.755	.2545	.1882	.2857				.2222	.1777	.0941		.0888	.2222		
25.	Toda Bhim																								.484	.1283	.1136				.0700	.0707	.0374		.0942	.0883		
26.	Bharatpur																									.095	.0840				.0784	.1045	.0276		.0697	.0653		
27.	Deeg																										.092	.0892	.0694	.0496	.0496		.0210	.0840	.0529	.0496		
28.	Nagar																											.106	.1111	.0900			.1428	.1568				
29.	Kaman																												.189	.0342		.2160						
30.	Weir																													.183			.0784					
31.	Nadbai																														.398	.2500	.0196		.0823	.0771		
32.	Mathura																															.277			.0658	.0617		
33.	Chhata																																.062	.0989	.0600		.0100	
34.	Agra																																	.183	.0900	.0925	.0200	
35.	Kiraoli																																		.192	.078		
36.	Rewari																																				.0101	
37.	Delhi																																				.0243	

CHAPTER IV

ROAD NETWORK DEVELOPMENT AND FLOW

In the earlier two chapters road network development and bus connectivity have been analysed. The aim of this chapter is to identify the nature of relationship between road network development and flow.

The road development index which reflects the extent of the transport activities in an area has an important bearing on bus connectivity. But there are some other forcestoo which affect the bus connectivity. Such factors may be the administrative importance of the area, markets, mandies, religious importance, topography, tourist places, etc. The role played by these factors varies from tehsil to tehsil. Though the network development and bus connectivity are supposed to be correlated, for a given level of transport development, there will be differentials in the bus connectivity in different regions, depending on the nature of the operation of the forces other than network development. An understanding of the extent and the nature of the forces which affect the bus connectivity besides the road development will further help in identifying the areas where these forces play a positive and negative role. It will further enhance the understanding of the existing bus connectivity. In this chapter an attempt has been made to find out the answers for the following questions:

1. Whether the intra tehsil bus connectivity (connectivity as the ratio of all the settlements within the tehsil) can be explained by road network development, and if so, what sort of relationship exists between the two?

2. Whether the intra tehsil bus connectivity (connectivity as the ratio of the settlements located along the roads) depends on road network development, and if so, what is the relationship between the two?

3. Up to what extent the inter tehsil bus connectivity (connectivity as the ratio of total settlements within the tehsil) is dependent upon road development?

4. Whether the inter tehsil bus connectivity (connectivity as the ratio of the settlements located along the roads) is dependent on road network development?

5. What is the relationship between intra tehsil bus connectivity and inter-tehsil bus connectivity (connectivity as the ratio of all the settlements within the tehsil).

6. What is the relationship between intra tehsil bus connectivity and inter tehsil bus connectivity (connectivity as the ratio of settlements located along the roads).

To see the relationship of above mentioned variables, Pearson's product-movement coefficient of correlation has been worked out as follows:

$$\gamma = \frac{\Sigma xy - \frac{\Sigma x \cdot \Sigma y}{N}}{\sqrt{\Sigma x^2 - \left(\frac{\Sigma x}{N}\right)^2} \times \sqrt{\Sigma y^2 - \left(\frac{\Sigma y}{N}\right)^2}}$$

*Y stands for bus connectivity and

*X stands for road network development

(which has been selected as an independent variable)

The significance of the coefficient of correlations has been tested by student's t test as given below:

$$t = r\sqrt{\frac{n-2}{1-r^2}} \quad \text{with n-2 degree of freedom}$$

Residuals from the regression have been used to identify the areas where beside the road development, the bus connectivity is affected by the other forces. The intensity of these forces depends upon the magnitude of the residuals. Thus the bus connectivity y has been linearly regressed on x (road network development). The constants of the regression line $y = a + bx$ have been estimated by the least square method. The estimated value of y is the average of different observed values of six variables selected corresponding to any given level of x. Difference of each y from its estimated mean value will be positive or negative if actual y is more than estimated y or less than estimated y. Therefore, by putting the value of road network development of each tehsil in the regression equation, the estimated value of bus connectivity has been computed and is denoted by $\hat{y}$. The residuals have been calculated by the difference between actual bus connectivity (y) and the estimated bus connectivity ($\hat{y}$). In order to have relative picture from the residuals they have been divided by the actual value. And thus the residuals given here are $\frac{y-\hat{y}}{y} \times 100$. The residuals have been

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* applicable only for first four sets.

divided into categories of positive and negative residuals. These are further subdivided into five or six categories and are plotted in fig. 22, 23, 24, 25, 26 and 27.

Results:

1. Residuals from the regression of intra-tehsil bus connectivity (connectivity as the ratio of the total settlements within the tehsil) on road network development:

The coefficient of correlation between road network development and intra tehsil bus connectivity is .32, which is significant at 5% level of significance for 35 degree of freedom. Though the coefficient is not very high but shows a tendency towards positive relationship and hence supports the statement mentioned above. The results of the regression analysis are:

$$Y = \frac{.001572 + .00157^{*}X}{(.0007716)^{@}}$$

$R^2 = .10$

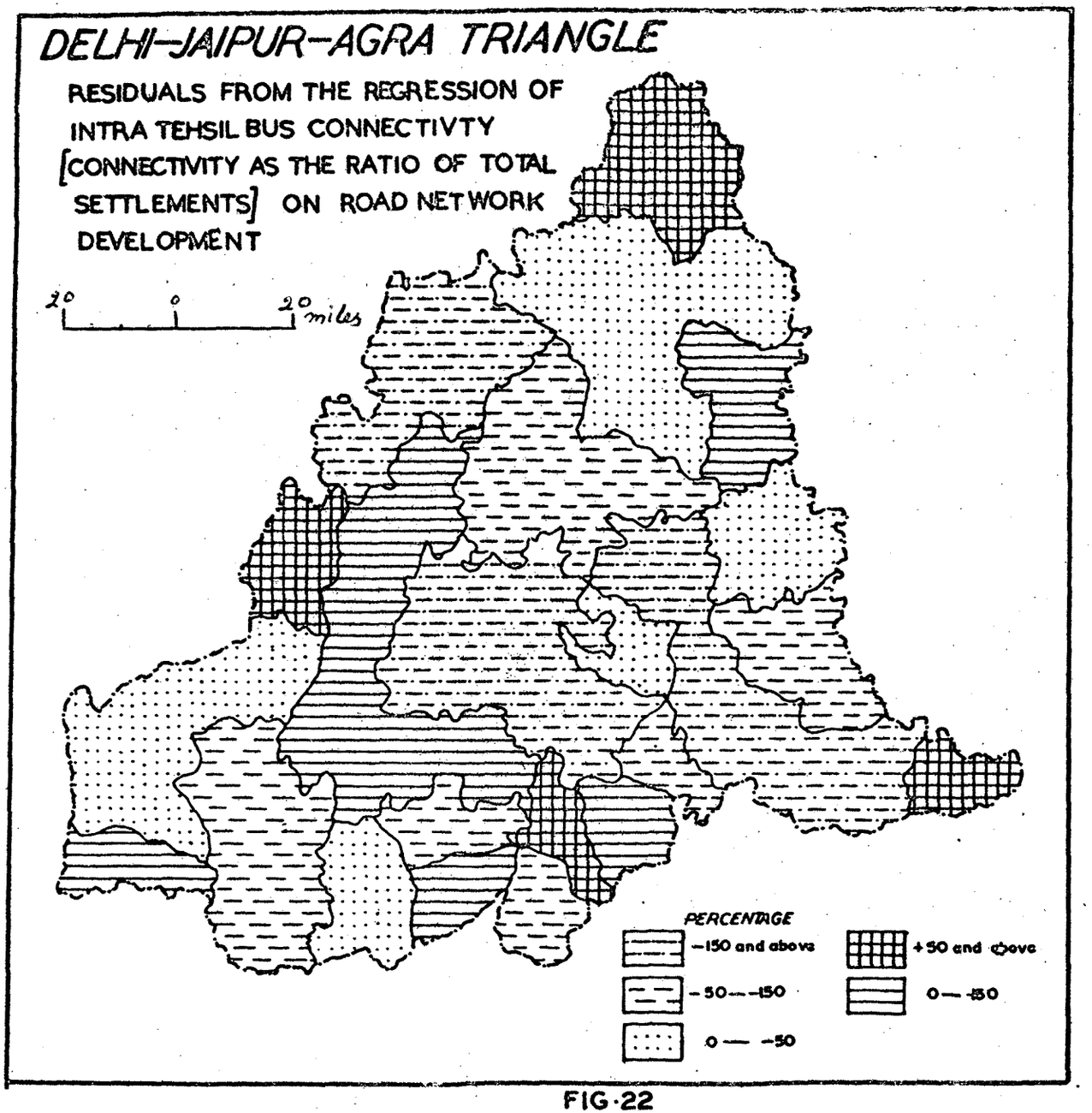
*Significant at 5% level of significance

@ Standard Error

As has already been noted that r is not very high, R^2 is only .10, but a significant b value certainly indicates that y is sensitive to x.

The results of the regression show wide regional variations as seen in fig.22.

Delhi, Agra, Mahwa and Kotputli tehsils have very high positive residuals, which do not make a contiguous region. They are located on the N.H. falling on the periphery of the region. The high positive residuals show that the areas have bus connectivity higher than the estimated bus connectivity


DELHI-JAIPUR-AGRA TRIANGLE
RESIDUALS FROM THE REGRESSION OF
INTRA TEHSIL BUS CONNECTIVTY
[CONNECTIVITY AS THE RATIO OF TOTAL
SETTLEMENTS] ON ROAD NETWORK
DEVELOPMENT
20 0 20 miles
PERCENTAGE
-150 and above
+50 and above
-50 — -150
0 — -150
0 — -50

FIG·22

based on the road network development. The possible reason is that Delhi is the national capital and a business centre, therefore, the people in large number enter and leave every day. Agra[1] city is the main trading centre in the tehsil and large number of people from within the tehsil also come and leave every day. This is important centre of the sales and purchase of agricultural commodities and industrial goods. Tehsil Mahwa also has important Mandi at Mandawar[2] where people gather very frequently.

Behror, Rewari, Kiraoli, Bharatpur and Alwar tehsils show very high negative residuals, which make a discontinuous belt extending from northwest to southeast across the region. In this belt of high negative residuals, some of the tehsils which reflect the under-utilization of road infra structure, are important from the point of view of trade, religious places and some tourist centres, e.g., Bharatpur and Alwar. These two are historical places where not only weekly markets and mandies function in large numbers but as well attract large number of local people on the occasions of certain festivals and fairs.* The map surprisingly does not show a very high bus connectivity keeping in view road network development. This may be primarily on account of other traffic vehicles used for transport, e.g., tongas, lorries, cycles, bullock carts, etc.

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1. Joshi E.B. (1965): Uttar Pradesh District Gazetteers: Agra, p.167, 177.

2. Census of India (1961): District Census Handbook, S.Madhopur, p.viii.

* (i) Census of India (1961) District Census Hand Book, Bharatpur, p.viii.
(ii) Census of India (1961) District Census Handbook, Alwar, p.vii.

In all the tehsils mentioned above which have high residuals, the intra tehsil bus connectivity is either greater or lesser than is indicated by the road network. This also means that in these tehsils, intra tehsil bus connectivity is not explained by road network development, but there are some other factors which have not been considered in the study. Some of them have been mentioned earlier.

On the other hand, Ballabgarh, Gurgaon and Nuh tehsils in the north, Amber and Bairath in the west, Chhata in east, Dausa in south and Nagar in the centre of the region, have very low negative residuals. This shows that in these parts of the region the road network is a better explanator of the bus connectivity. The effect of factors other than road network is much less.

Along the western fringe of the Aravalli hills and in the tehsils of Jaipur, Weir, Sikrai and Palwal, the positive residuals are of least magnitude. This show that the road network development index is an important explanatory variable. The effect of other variables is not much but it is in positive direction. Taking the region as a whole, road network development index explains about 10% variation in the intra tehsil bus connectivity. The balance of variation in the intra tehsil bus connectivity is explained by some other factors. Some of them have been mentioned earlier.

The fact which needs to be mentioned here is that the development of road network does not imply that buses alone

will utilize it but there are other means of transport as well, i.e., private passenger and freight transport which might be using the roads. Thus if all means of road transport are combined together, the road network development might be a dominating explanatory variable.

2. Residuals from the regression of intra tehsil bus connectivity (connectivity as the ratio of total settlements on the roads) and road network development:

The coefficient of correlation between two variables is -.41, which is significant at 1% level of significance for 35 degrees of freedom. The results of the regression are mentioned below:

$$Y = .326465 - \underset{(.044756)@}{.12076^{*}X}$$

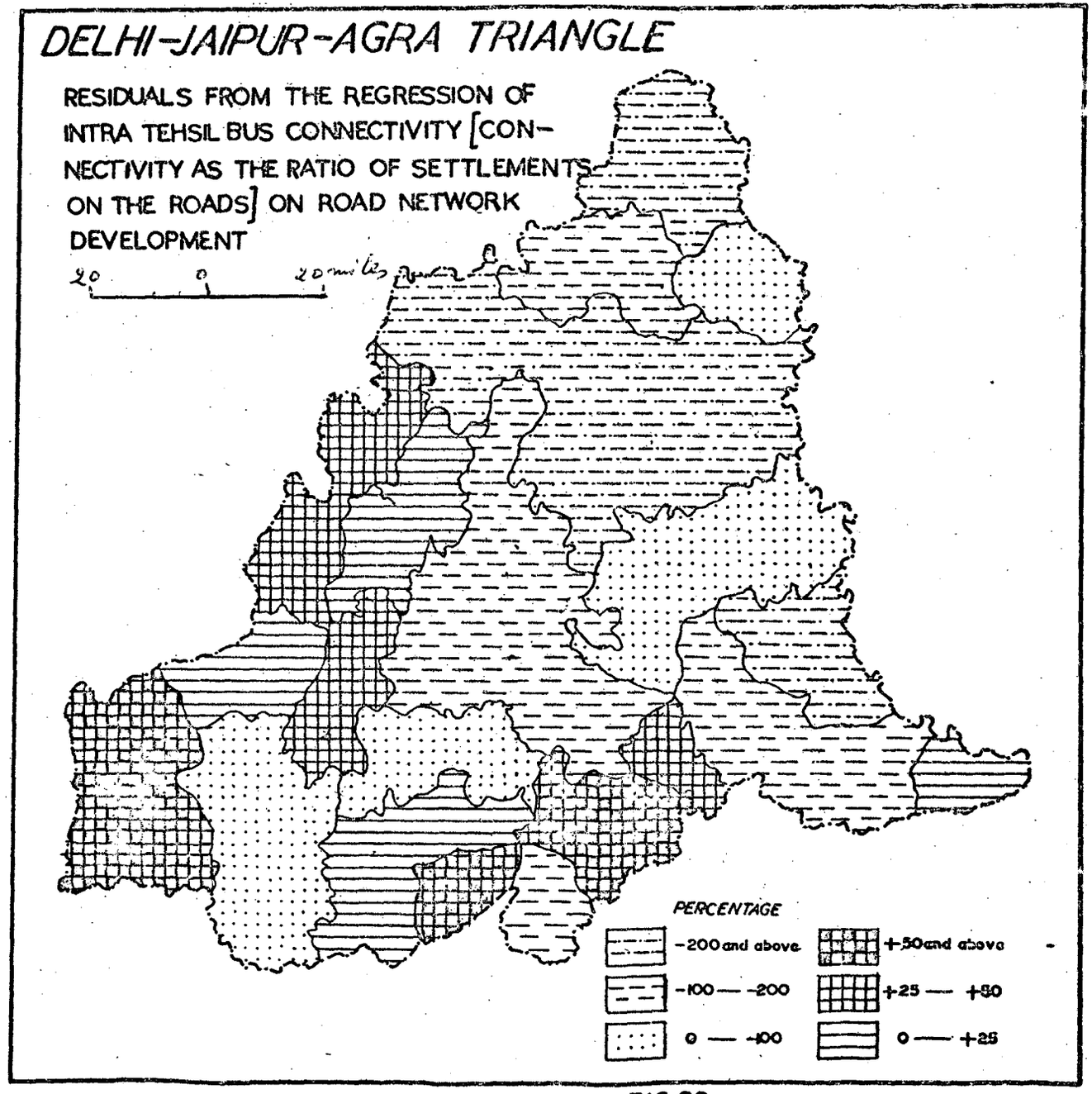
$$R = .17$$

*Significant at 1% level of Significance

R^2 is only .17 but a significant b value certainly shows that y is sensitive to x.

The residuals have been depicted in figure No. 23. There are only 8 tehsils in the region where the magnitude of the residuals is less than 25%. 21 tehsils of the region have more than 50% deviations from the regression line.

Fig. 23 shows that most of the tehsils which have very high positive residuals lie in the southern and western part of the region. These high positive residuals show that this is the part of the region where intra tehsil bus connectivity is much more than the expected average bus connectivity from the road


DELHI-JAIPUR-AGRA TRIANGLE
RESIDUALS FROM THE REGRESSION OF INTRA TEHSIL BUS CONNECTIVITY [CONNECTIVITY AS THE RATIO OF SETTLEMENTS ON THE ROADS] ON ROAD NETWORK DEVELOPMENT
20 0 20 miles
PERCENTAGE
-200 and above
-100 — -200
0 — -100
+50 and above
+25 — +50
0 — +25

FIG·23

network development. The possible reason for high positive residuals is that Jaipur is the capital of Rajasthan, Amber has many temples of historical importance and Mahwa has important mandi. These factors lead to high mobility and resulting into high bus connectivity.

The northern part of the region and Mathura tehsil in the south-east have very high negative residuals, i.e., where the bus connectivity is much less than the one predicted from the road network development.

Jamwa Ramgarh, Bassi and Rajgarh in the south-western part of the region, Ballabgarh in the north-east, Nagar, Chhata and Kaman in mid-east show very low negative residuals.

Except Agra, other tehsils of low positive residuals are located in south-west of the region. These are the tehsils where network and bus connectivity has more effective relationship.

The road network development index can explain only 17% variation in the intra tehsil bus connectivity. The unexplained variation may be due to some other factors as mentioned earlier.

Another problem is that of negative correlation where the road network development is high, there the intra tehsil bus connectivity is low and vice-versa. This may be understood by the following phenomena.

In the northern part of the region, particularly Haryana, has very high development of roads. So many roads

have been constructed in the last few years. But the buses are not plying on all the roads because the people do not have a demand for that, which is the nature of an under-developed economy.

3. Residuals from the regression of inter tehsil bus connectivity (connectivity as the ratio of total settlements) on road network development:

The coefficient of correlation between road network development and inter tehsil bus connectivity is .50 which is significant at 1% level of significance for 35 degress of freedom. The relationship is positive which supports the third statement as mentioned in the beginning. The results of the regression are:

$$Y = .000138 + \underset{(.0000434)@}{.000153^{*}x}$$

$$R^2 = .25$$

*Significant at 1% level of significance.

Though the R^2 is only .25 but the significant b value definitely shows that y is sensitive to x.

If a particular tehsil has efficient road network that also means that it should be linked through buses from different tehsils, because generally the buses cannot terminate just at the border of a tehsil. In other words, inter tehsil bus connectivity should be dependent on how the existing network links one tehsil with the others.

Agra in the east, Mahwa and Sikrai in the south, Kotputli and Bairath in the west, are the pockets which have much higher inter tehsil but connectivity as compared to expected connectivity

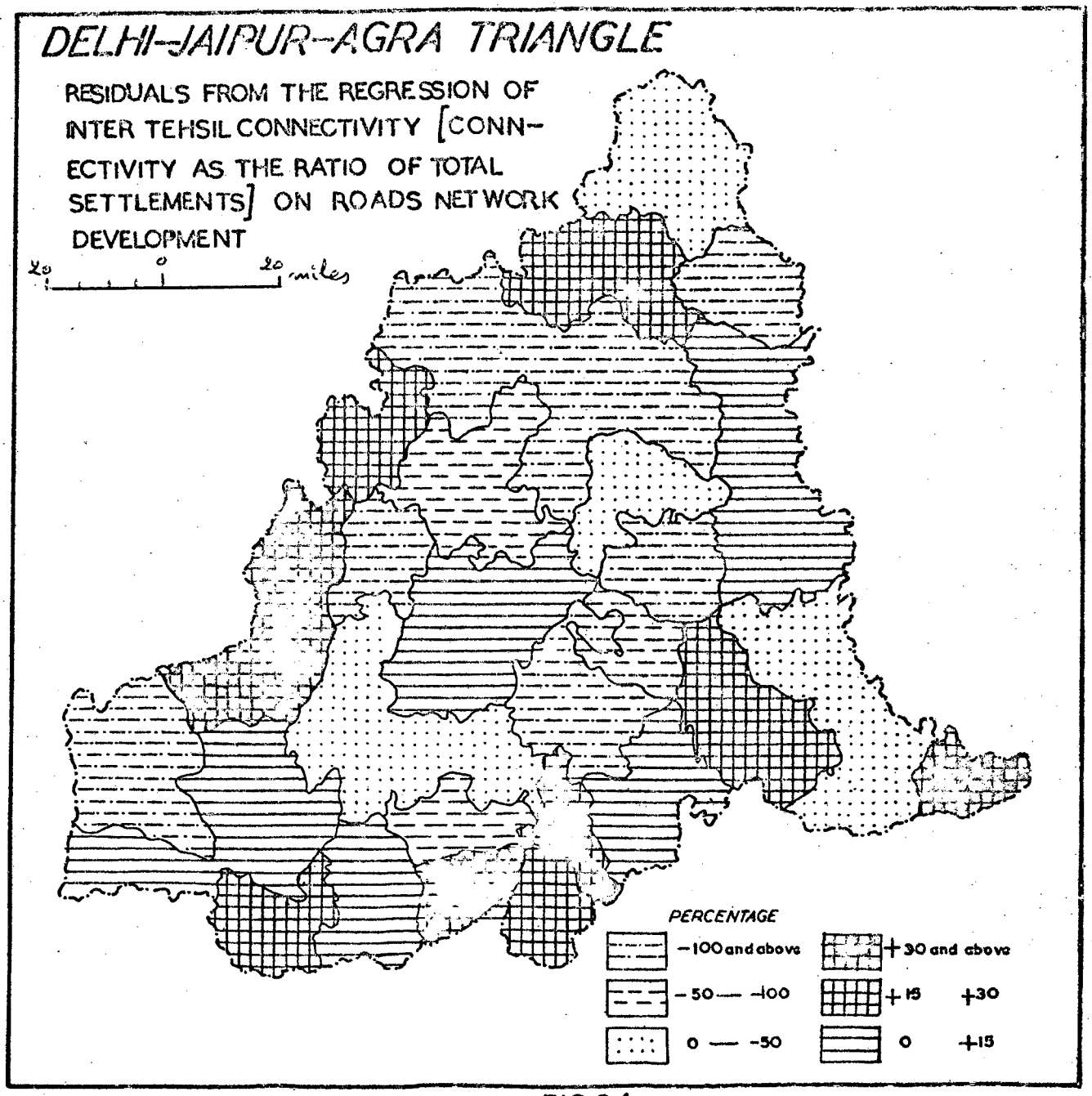

DELHI-JAIPUR-AGRA TRIANGLE
RESIDUALS FROM THE REGRESSION OF INTER TEHSIL CONNECTIVITY [CONNECTIVITY AS THE RATIO OF TOTAL SETTLEMENTS] ON ROADS NETWORK DEVELOPMENT
20 0 20 miles
PERCENTAGE
-100 and above
-50 — -100
0 — -50
+30 and above
+15 +30
0 +15

FIG-24

from road network development (fig.24). The areas of high negative residuals are contiguous in the northern part of the region. In the remaining region the pockets of high negative residuals make scattered appearance.

Almost all the tehsils (except (Alwar and Deeg) where the inter tehsil bus connectivity is higher than the expected connectivity from the road network, do lie at the outer margins of the region and corssed by nation highways. The possible reasons for high positive residuals at national highway is that it links a particular tehsil at greater distances also. So the inter tehsil movement of such tehsils is much more high as compared to those which are located at minor routes. This means that national highway is very important in promoting the connections of one tehsil with the others.

The road network development can explain 25% variation in the inter tehsil but connectivity.

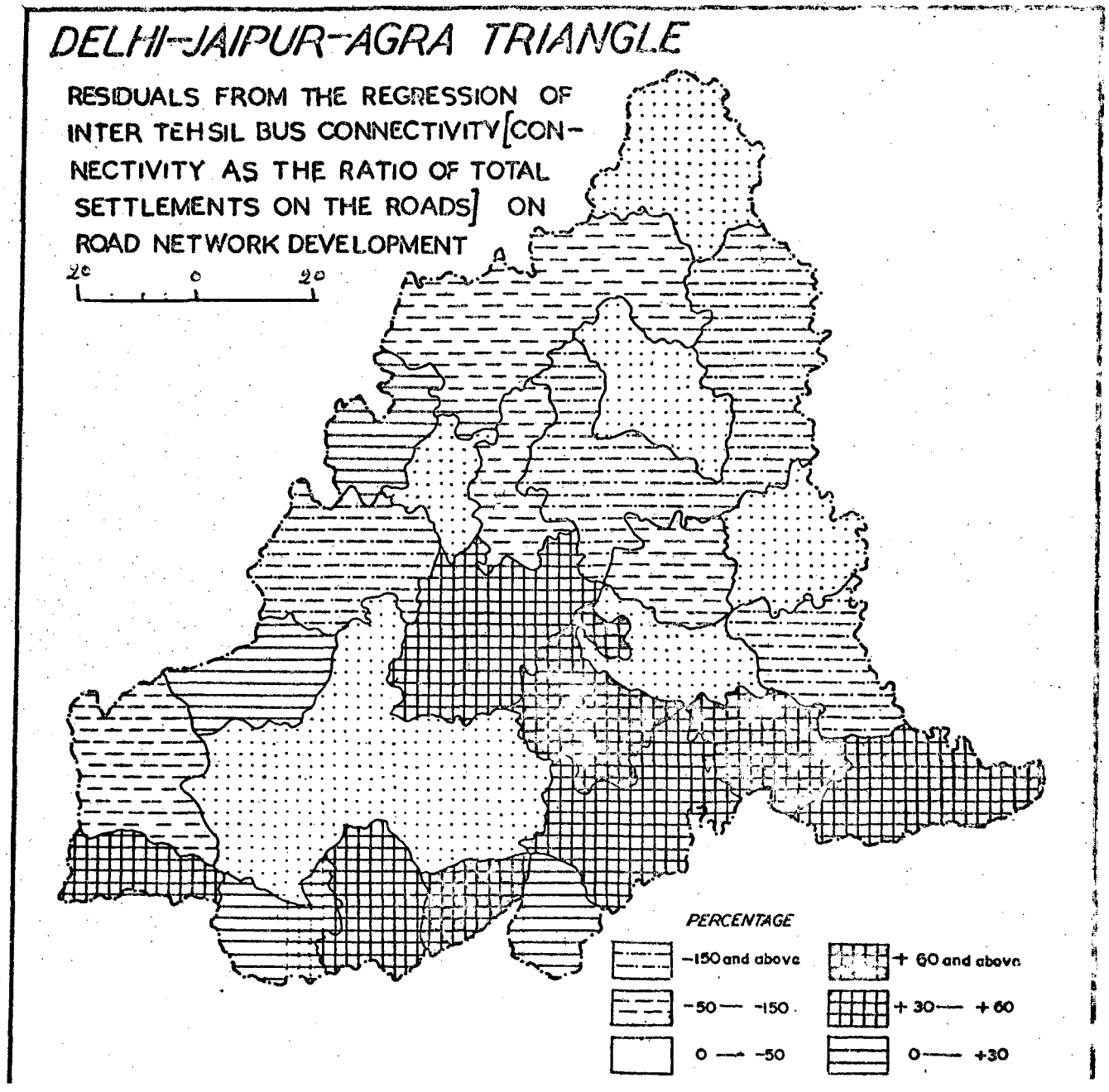
4. Residuals from the regression of inter tehsil bus connectivity (connectivity as the ratio of settlements on the roads) on road network development:

The coefficient of correlation between two is -.35, which shows negative relationship between them. This is significant at 2% level of significance for 35 degrees of freedom. The regression results are given below:

$$Y = .026607 - \underset{(.00382)@}{.008635^{*}x}$$

$$R^2 = .12$$

* Significant at 2% level of significance.


DELHI-JAIPUR-AGRA TRIANGLE
RESIDUALS FROM THE REGRESSION OF INTER TEHSIL BUS CONNECTIVITY [CONNECTIVITY AS THE RATIO OF TOTAL SETTLEMENTS ON THE ROADS] ON ROAD NETWORK DEVELOPMENT
20 0 20
PERCENTAGE
-150 and above
-50 — -150
0 — -50
+ 60 and above
+ 30 — + 60
0 — +30

The R^2 is only .12 but the significant b value certainly indicates that y is sensitive to x.

There is significantly negative relationship between the two, where the road network is very efficient, there the buses are not plying on all the roads. All those tehsils where there is high under-estimation of inter tehsil bus connectivity or in other words where the bus connectivity is much higher than expected connectivity from the road network development, are located in southern part of the region. This indicates that in southern part of the region factors other than road network are more effective in positive direction.

If we see fig.No.25, we observe that whole of the northern and north-eastern region and a big chunk of area in southwest represents negative residuals, i.e. where the road network is under utilized. Some of the possible reasons have been given already.

5. Residuals from the regression of intra tehsil bus connectivity on inter tehsil bus connectivity (connectivity as the ratio of total settlements):

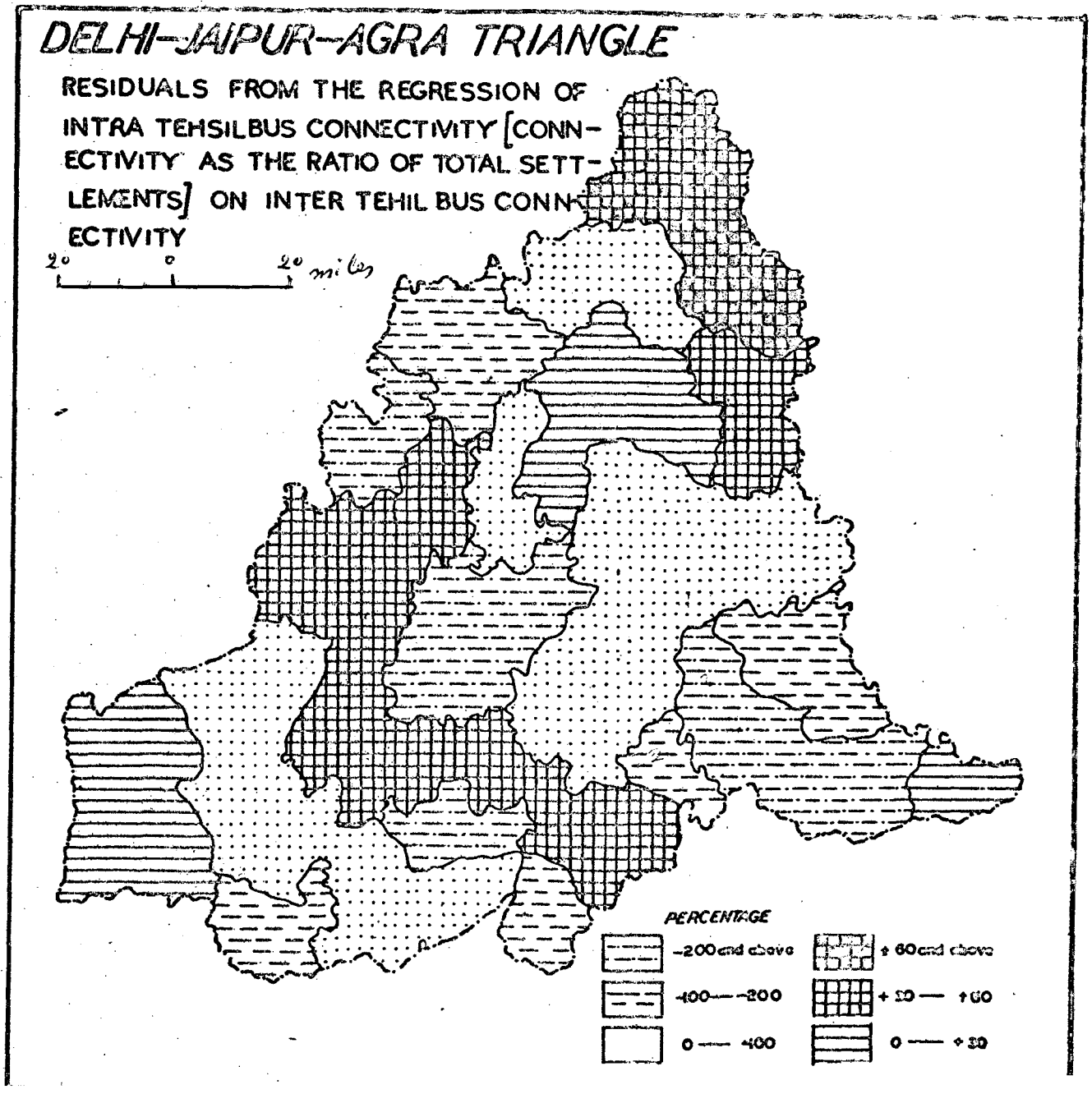
The coefficient of correlation between two variables is .49, which shows positive relationship and significant at 1% level of significance for 35 degrees of freedom. The regression results are as follows:

$$Y = .000701 + \underset{(.001)@}{8.4x^{*}}$$

$$R^2 = .24$$

*Significant at 1% level of significance.

3


DELHI-JAIPUR-AGRA TRIANGLE
RESIDUALS FROM THE REGRESSION OF INTRA TEHSILBUS CONNECTIVITY [CONNECTIVITY AS THE RATIO OF TOTAL SETTLEMENTS] ON INTER TEHIL BUS CONNECTIVITY
20 0 20 miles
PERCENTAGE
-200 and above
-400 — -200
0 — -400
+ 60 and above
+ 20 — + 60
0 — + 20

Though R^2 is only .24 but the significant b value certainly indicates that y is sensitive to x.

A particular tehsil is better linked with other tehsils because some important centres are located there in the tehsil within the tehsil also, if there is some awareness among the people of the importance of those centres, it should be well connected to these centres. Fig.26 shows that in the extreme noth of the region we observe high intra tehsil bus connectivity than the expected intra tehsil bus connectivity from inter tehsil bus connectivity. There is a contiguous belt of medium positive residuals in the southwestern part of the region. Behror, Alwar, Kotputli, Deeg, Baswa are the tehsils where the intra tehsil bus connectivity is much over estimated. This shows that the inter tehsil but connectivity is not the important effective explanatory variable but some other variables have very high negative effect.

Here the inter tehsil bus connectivity explain only 25% variation in intra tehsil bus connectivity.

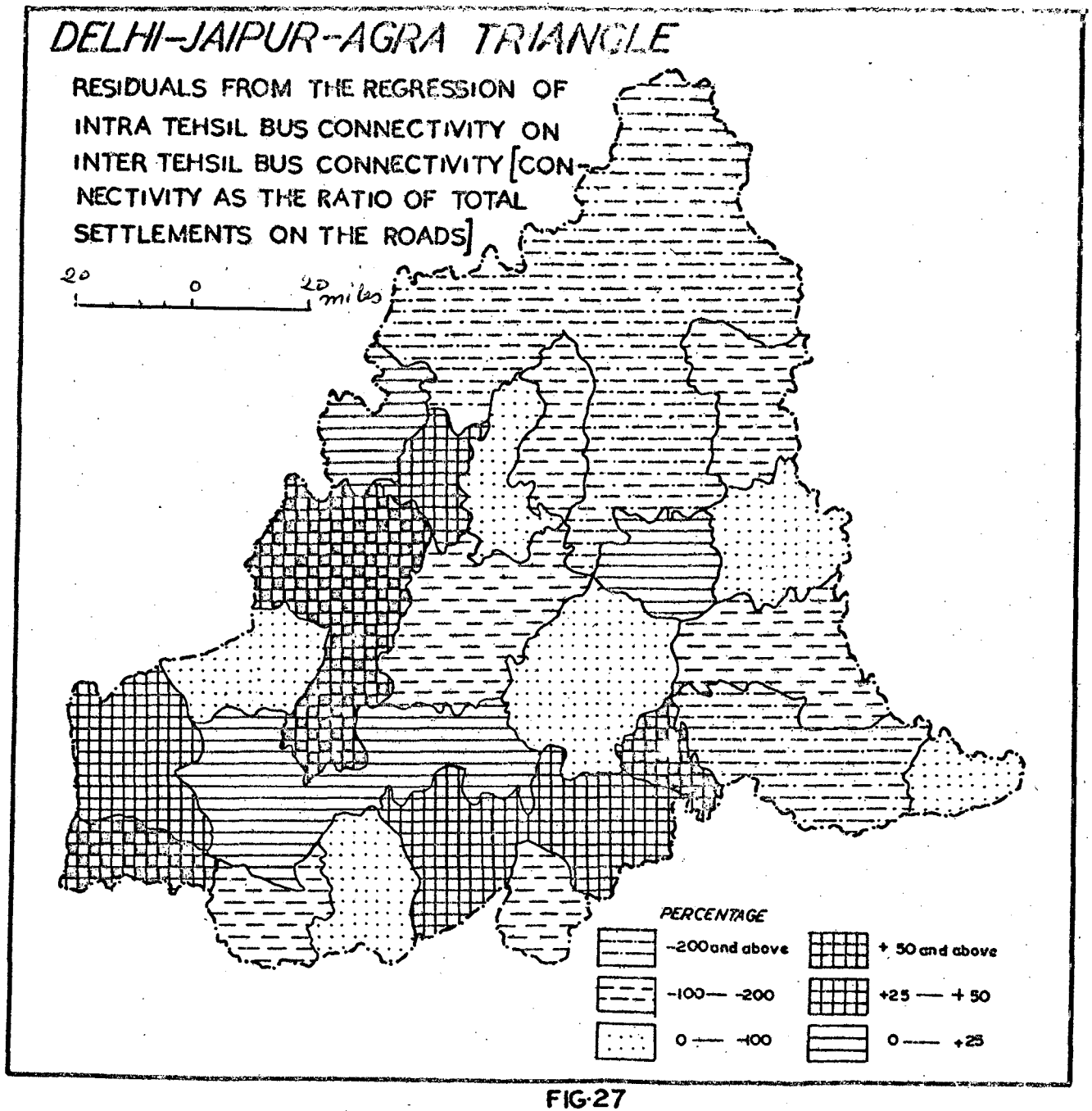
6. Residuals from the regression of intra tehsil bus connectivity on inter tehsil bus connectivity (connectivity as the ratio of settlements on the roads):

The coefficient of correlation between two is .58 which is significant at 1% level of significance for 35 degrees of freedom. The regression results are as follows:

$$Y = .079204 + \underset{(1.6172)@}{6.99^{*}_{x}}$$

$$R^2 = .34$$

*Significant at 1% level of significance.


DELHI-JAIPUR-AGRA TRIANGLE
RESIDUALS FROM THE REGRESSION OF INTRA TEHSIL BUS CONNECTIVITY ON INTER TEHSIL BUS CONNECTIVITY [CONNECTIVITY AS THE RATIO OF TOTAL SETTLEMENTS ON THE ROADS]
20 0 20 miles
PERCENTAGE
-200 and above
-100 — -200
0 — -100
+ 50 and above
+25 — + 50
0 — +25

FIG·27

The significant b value shows that y is sensitive to x.

Fig.27 shows that northern part of the region has very low intra tehsil bus connectivity than expected from inter tehsil bus connectivity. Southern and southwestern part of the region has high intra tehsil bus connectivity than expected from inter tehsil bus connectivity.

In this set the inter tehsil bus connectivity can explain 34% variation in intra tehsil bus connectivity.

The following <u>conclusions</u> can be drawn:

1. Intra tehsil bus connectivity (connectivity as ratio of total settlements) is dependent on road network development. There is a positive relationship between the two. The road network development can explain only 11% variation in the intra tehsil bus connectivity (connectivity as ratio of total settlements).
2. Intra tehsil bus connectivity (connectivity as ratio of settlements on the roads) can be explained only 17% by road network development. The relationship between two is negative and significant.
3. Inter tehsil connectivity (connectivity as ratio of total settlements) and road network development is also positively correlated. Only 25% of it can be explained by road network development.
4. There is negative correlation between inter tehsil bus connectivity (connectivity as the ratio of settlements on the roads) and road network development. Here

road network development can explain only 12% variation in the inter tehsil bus connectivity (connectivity as the ratio of settlements on the roads).

5. Inter tehsil connectivity can explain 25% variation in the intra tehsil bus connectivity (connectivity as ratio of total settlements).

6. Inter tehsil bus connectivity can explain about 33% variation in intra tehsil bus connectivity (connectivity as the ratio of total villages on the roads).

CHAPTER V

SUMMARY AND CONCLUSION

A critical analysis of the transport development in the Delhi-Jaipur-Agra triangle, which covers 37 tehsils from the States of Delhi, Haryana, Rajasthan and Uttar Pradesh highlights quite a few salient points worth enumeration. The analysis which is based on bus connections and transport linkages, shows that the region has a fairly high level of road network development. This is evident from the fact that nearly 63% of settlements in the entire region are within a distance of two miles from the metalled roads; 32% from 2 to 4 miles and 5% beyond 4 miles from the roads. The existing standards of the road network seem to be higher than the ones proposed by chief engineers in 1958 in the Road Development Plan, for India (1961-1981). Within the region, the tehsils of north like Delhi and Gurgaon, which have the highest level of road network development, do not have a single village more than 4 miles away from the road. 90% of the settlements of these tehsils are within a distance of two miles from the roads.

It has, however, been observed that all the indicators of road network development are not uniformally effective throughout the region. Cyclamatic number and alpha indices are most effective in the northern part of the region. National highway accessibility index (H) is most effective in south and southwest along the national highway. (Alpha, Beta and cyclamatic numbers play the dominating role in the composition of road network development index as reflected from the coefficients of correlation values).

National highways play a major role in determining the degree and range of connections of settlements and national highways, have their connections for a longer range of distance. Almost all tehsils in the south along Jaipur-Agra national highway show high distance range and high connectivity. All the high distance range connections are gravitated towards Agra, Delhi and Jaipur, thus indicating their tendency to be closely linked with the national highways and larger urban centres. However, the tehsils along one national highway do not have interactions with the tehsils of another national highway. Alwar is an exception which has its direct connections with all the three national highways. It has been observed that the tehsils which are in the middle of the region and are not traversed by any of the national highways, have low distance range, though have high connectivity.

Intra tehsil bus connectivity is very high in the northern part of the region if it is calculated as ratio to maximum possible connectivity of the settlements. It becomes very low if its ratio is taken to the maximum possible connectivity of settlements along the roads. The analysis shows that the road network development and intra/inter tehsil bus connectivity (connectivity as the ratio to maximum possible connectivity of settlements along the roads) are negatively correlated to each other. Where the levels of road network development are low there the intra/inter tehsil bus connectivity is high and vice versa. Road network development and intra/inter tehsil bus connectivity (connectivity as the ratio to maximum possible connectivity of settlements)

have positive relationship. Where the road network development is high, there the bus connectivity is also high.

The level of transport development in the region has shown a positive relationship with the level of its economic development, the later having been obtained from M.N. Pal's criteria of measuring the level of economic development in this region (Chapter I). It has been observed that the northern part of the region, which according to M.N. Pal, has high level of economic development, has a high level of transport development according to our investigations. Not only the pattern of road network is quite complex but is also circumvented in such a fashion as to cover quite a few villages. This is specially so in the tehsils of Haryana (Map No.3a). The middle region covering the districts of Alwar, Bharatpur and Sawai Madhopur, which has low level of economic development, also has a low level of transport development. Hilly topography, however, seems to be the main factor in the low transport network development. Similarly, the south-western part of the region which has low level of economic development, faces low level of transport development.

Through the analytical sketch of data, though we are in a position to deduce a relationship between the levels of economic development and those of transport development, we are not in a position to judge whether one is the cause or the effect of the other. A time series analysis of the two types of indicators of development might lead us to a vicious circle where the level of economic development is high because the level of transport development is high or vice versa, or else it might lead us to some concrete conclusion, an aspect which could be taken up for further investigation.

Though the region on the whole has a fairly high level of transport development, there are vast intra regional variations, which are more distinct as one moves from north to south or from the national highways to the interior of the region. Thus there is a lot of scope for further improvement. The map of transport lines maps still shows vast areas where the roads have not been laid still and which need to be immediately laid to connect the remote settlements with the national highways or with the urban centres. Once the road-network is laid, the bus connections will follow, thus improve interactions. The following missing links could be taken up in the first phase of programme.

The Chhata tehsil which falls in an agriculturally developed district has 68% of the villages more than 2 miles away from the roads. A road stretch of 25 miles should be laid down starting from Chhata towards Achhnera, crossing Goverdhan-Mathura route and Bharatpur-Mathura route. By this additional road large number of villages of Chhata and Mathura tehsil will come within 2 miles from the roads. These additional villages will be linked to Mathura, Agra and Bharatpur, thus linking to national highway. This agriculturally developed area will further develop due to improved transportation. In southwestern part of the region, though, there are topographic constraints but the additional increase in road will definitely add to economic development. There should be direct links from Govindgarh to Deeg and Nagar to Bharatpur, which may link these villages with Jaipur-Agra national highway and ~~will~~ make many villages accessible to the roads.

Table No. 10

Appendix I

(a) Residuals from the regression of intra-tehsil bus connectivity (connectivity as the ratio of the total settlements within the tehsil) on road network development

1.	Behror	-560.00
2.	Rewari	.354.54
3.	Kiraoli	-350.00
4.	Bharatpur	-312.50
5.	Alwar	-244.44
6.	Kaman	-175.00
7.	Deeg	-155.55
8.	Lachhmangarh	-155.55
9.	Baswa	-130.00
10.	Kishangarh	-127.27
11.	Mathura	-123.07
12.	Bassi	-118.18
13.	Nadbai	-106.66
14.	Tijara	-100.00
15.	Toda Bhim	- 84.61
16.	F.Jhirka	- 80.28
17.	J. Ramgarh	- 76.92
18.	Dausa	- 43.75
19.	Chhata	- 38.88
20.	Nagar	- 21.05
21.	Amber	- 16.00
22.	Nuh	- 14.28
23.	Bairath	- 13.63
24.	Gurgaon	- 8.30
25.	Ballabgarh	- 8.00
26.	Mahwa	+ 72.16
27.	Kotputli	+ 71.13
28.	Delhi	+ 60.50
29.	Agra	+ 52.63
30.	Rajgarh	+ 50.94
31.	Thanagazi	+ 46.80
32.	Palwal	+ 39.28
33.	Weir	+ 33.96
34.	Sikrai	+ 27.03
35.	Jaipur	+ 26.00
36.	Bansur	+ 21.87
37.	Mandawar	+ 8.57

(b) Residuals from the regression of intra tehsil bus connectivity (connectivity as the ratio of total settlements on the roads) and road network development

1.	F. Jhirka	-750.00
2.	Rewari	-520.00
3.	Palwal	-402.77
4.	Nuh	-350.00
5.	Tijara	-303.27
6.	Mathura	-259.66
7.	Delhi	-186.20
8.	Toda Bhim	-175.78
9.	Deeg	-158.49
10.	Lachhmangarh	-151.85
11.	Gurgaon	-131.57
12.	Kishangarh	-122.41
13.	Kiraoli	-120.51
14.	Bharatpur	-108.69
15.	Alwar	-108.08
16.	Ballabgarh	- 68.42
17.	Kaman	- 50.03
18.	Chhata	- 44.75
19.	Bassi	- 38.03
20.	Nagar	- 25.40
21.	Rajgarh	- 17.24
22.	J. Ramgarh	- 11.57
23.	Amber	+288.50
24.	Jaipur	+ 70.45
25.	Sikrai	+ 68.24
26.	Weir	+ 55.52
27.	Mahwa	+ 51.13
28.	Kotputli	+ 44.89
29.	Behror	+ 41.12
30.	Thanagazi	+ 37.12
31.	Nadbai	+ 25.63
32.	Baswa	+ 19.21
33.	Agra	+ 13.01
34.	Mandawar	+ 10.45
35.	Dausa	+ 8.50
36.	Bansur	+ 7.29
37.	Bairath	+ 1.56

(c) Residuals from the regression of inter tehsil bus connectivity (connectivity as the ratio of total settlements) on road network development

1.	Ballabgarh	-690.90
2.	Tijara	-242.85
3.	Bansur	-187.50
4.	Amber	-140.00
5.	Kaman	-122.22
6.	Lachhmangarh	-110.00
7.	Nuh	-109.52
8.	Rewari	-104.34
9.	Baswa	- 90.90
10.	Kishangarh	- 61.53
11.	Nagar	- 56.25
12.	Mandawar	- 52.63
13.	Mathura	- 34.28
14.	Kiraoli	- 26.92
15.	Rajgarh	- 20.00
16.	Thanagazi	- 9.52
17.	F. Jhirka	- 7.31
18.	Delhi	- 7.14
19.	Kotputli	+ 70.90
20.	Mahwa	+ 52.83
21.	Bairath	+ 47.72
22.	Agra	+ 40.35
23.	Sikrai	+ 39.21
24.	Toda Bhim	+ 29.83
25.	Behror	+ 25.00
26.	Bharatpur	+ 24.39
27.	Gurgaon	+ 23.07
28.	Bassi	+ 17.85
29.	Deeg	+ 16.00
30.	Chhata	+ 14.81
31.	Dausa	+ 13.79
32.	Jaipur	+ 10.52
33.	Nadbai	+ 9.37
34.	Palwal	+ 8.57
35.	Alwar	+ 6.45
36.	J. Ramgarh	+ 4.54
37.	Weir	+ 3.30

(d) Residuals from the regression of inter tehsil bus connectivity (connectivity as the ratio of settlements on the roads) on road network development

1.	Kotputli	-783.10
2.	Tijara	-435.56
3.	Ballabgarh	-323.07
4.	Palwal	-318.15
5.	Mathura	-236.51
6.	Bansur	-224.24
7.	F. Jhirka	-181.81
8.	Kaman	-150.78
9.	Kishangarh	-116.80
10.	Gurgaon	- 92.19
11.	Rewari	- 72.72
12.	Amber	- 59.08
13.	Mandawar	- 50.00
14.	Thanagazi	- 48.61
15.	Chhata	- 39.35
16.	Rajgarh	- 33.16
17.	J. Ramgarh	- 22.88
18.	Nagar	- 21.30
19.	Baswa	- 20.43
20.	Delhi	- 20.19
21.	Nuh	- 7.2
22.	Deeg	- 5.5
23.	Lachhmangarh	+133.74
24.	Sikrai	+ 70.23
25.	Bharatpur	+ 65.80
26.	Mahwa	+ 45.60
27.	Nadbai	+ 43.27
28.	Weir	+ 40.46
29.	Dausa	+ 40.10
30.	Jaipur	+ 35.91
31.	Kiraoli	+ 31.70
32.	Agra	+ 31.50
33.	Alwar	+ 29.47
34.	Bairath	+ 29.38
35.	Toda Bhim	+ 10.88
36.	Bassi	+ 9.2
37.	Behror	+ 5.9

(e) Residuals from the regression of intra tehsil bus connectivity on inter tehsil bus connectivity (connectivity as the ratio of total settlements)

1.	Behror	-700.00
2.	Bharatpur	-412.50
3.	Alwar	-266.67
4.	Kiraoli	-262.50
5.	Baswa	-240.00
6.	Deeg	-211.11
7.	Mathura	-176.92
8.	Bassi	-172.73
9.	Toda Bhim	-153.85
10.	Rewari	-136.36
11.	Nadbai	-126.67
12.	Bairath	-100.00
13.	Dausa	- 93.72
14.	J. Ramgarh	- 92.31
15.	Kaman	- 75.00
16.	Lachhmangarh	- 66.67
17.	Chhata	- 66.67
18.	Kishangarh	- 63.64
19.	F. Jhirka	- 57.19
20.	Sikrai	- 32.43
21.	Gurgaon	- 29.17
22.	Nagar	- 5.25
23.	Ballabgarh	+ 86.00
24.	Delhi	+ 64.71
25.	Bansur	+ 56.25
26.	Rajgarh	+ 54.72
27.	Mahwa	+ 47.42
28.	Thanagazi	+ 46.81
29.	Kotputli	+ 45.36
30.	Palwal	+ 35.71
31.	Mandawar	+ 34.29
32.	Weir	+ 33.96
33.	Jaipur	+ 28.00
34.	Agra	+ 27.63
35.	Amber	+ 24.00
36.	Nuh	+ 10.71
37.	Tijara	+ 1.53

(f) Residuals from the regression of intra tehsil bus connectivity and inter tehsil bus connectivity (connectivity as the ratio of settlements on the roads)

1.	Rewari	-1000.00
2.	F. Jhirka	- 920.00
3.	Gurgaon	- 436.84
4.	Nuh	- 380.00
5.	Bharatpur	- 365.21
6.	Ballabgarh	- 363.15
7.	Delhi	- 272.4
8.	Kiraoli	- 205.12
9.	Palwal	- 194.44
10.	Mathura	- 187.09
11.	Toda Bhim	- 164.21
12.	Alwar	- 159.59
13.	Deeg	- 113.20
14.	Tijara	- 73.7
15.	Bassi	- 50.30
16.	Lachhmangarh	- 36.11
17.	Kishangarh	- 27.58
18.	Agra	- 21.87
19.	Dausa	- 15.98
20.	Bairath	- 8.59
21.	Nagar	- 3.17
22.	Chhata	- 2.18
23.	Kotputli	+ 78.38
24.	Nadbai	+ 71.11
25.	Jaipur	+ 56.39
26.	Thanagazi	+ 55.69
27.	Bansur	+ 54.37
28.	Amber	+ 47.93
29.	Baswa	+ 37.24
30.	Weir	+ 32.91
31.	Mahwa	+ 30.78
32.	Mandawar	+ 27.27
33.	Sikrai	+ 26.85
34.	Kaman	+ 25.13
35.	Behror	+ 17.23
36.	J. Ramgarh	+ 14.46
37.	Rajgarh	+ 9.66

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