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Trends and Patterns of Road Infrastructure in India, 1971-2011

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Abstract: *Roads are the key to the development of an economy. A good road network constitute the basic infrastructure that propels the development process through connectivity and opening up of the backward regions to trade and investment. In this paper, an attempt has been made to analyze the road infrastructure in India at the district level for three reference periods i.e. 1971, 1991 and 2011. The base of the study is secondary data obtained from directorate of economic and statistics of individual state/UT and Census of India, Delhi. The road infrastructure has been assessed in term of road length in relation to geographic area and per size of population. In order to find out the extent and magnitude of the disparity in existing road infrastructure Z-score and Co-efficient of variation techniques have been employed. It has been investigated that the road length has increased from 23.75 kms in 1971 to 142.68 kms per 100 sq km in 2011 and thus witnessed about six times increase during last 40 years. Similarly, the availability of roads per 10,000 of population also increased from 14.24 kms in 1971 to 38.14 kms in 2011. The study reveals the prevalence of inter-regional or inter-districts disparities in availability of roads both in terms of area and population at the district level. The coastal and northern plain of India are sufficiently endowed with the road infrastructure whereas these facilities are wanting very much in the mountainous area, desert and peninsular part of the study area. Furthermore, the study stressed that the widening inter-district disparities in level of road infrastructure both in terms of geographical area and per size of population needs closer attention of development planners and policy makers.*

Key Words: Road Length, Area, Population, Trends, Patterns

Introduction:

Transport is an essential category of infrastructure for rapid development of any region. The lack of transport facilities retards the economic development even if a region is endowed with rich natural resources (Dash, 2008, p. 9). Therefore, an effective transport system is crucial for sustained economic growth and modernization of economy. Transport system is necessary for connecting villages with towns, market centres and in bringing together remote and developing regions closer to one another (Arasu, 2008, p. 155). The lack of transport and communication facilities accentuates regional imbalances and keeps certain areas in perpetual poverty and deprivation (Tiwari, 2000, p. 15; Poonia *et al*, 2009, p. 105). In India, there are four main modes of transportation namely road, rail, air and water. Among these modes of transportation, the place of roads is most dominant particularly in the context of India. The road transportation is very significant for the development of a society because it is considered economically viable mode of transport for short and medium distances and easily accessible to remote and harsh areas (Patra, 2014, quoted from Mangat and Gill, 2015, p. 87). Roads are also the key to the development of an economy. A good road network constitute the basic infrastructure that propels the development process through connectivity and opening up of the backward regions to trade and investment. Roads also play a key role in inter-nodal transport development, establishing links with air ports, railway stations and ports (Saxena, 2005, p. 23). In additions, roads are strategically important as they promote national integration which is particularly necessary in a large country like India.

In India, for the purpose of management and administration roads are divided into different categories like i.e. National Highways, state highways, districts roads and rural roads (Jetli and Sethi, 2007, p. 67). Although, India has four main modes of transportation namely road, rail, air and water. But the vast geographical expansion of the country allows only road transport to be the major mode of transportation along with rail and air transportation. Therefore, in present study, the road length both in terms of per size of geographical area and population served have been used to assess the transportation infrastructure development at the district level.

Objectives of the Study:

The present study aims at investigating the following two fold objectives:

i) To study the trends and patterns in level of road infrastructure in terms of geographical area and per size of population.

ii) To examine the extent and magnitude of the regional disparities in the availability of road infrastructure.

Data Base and Research Methods

The present study is based on secondary data of 1971, 1991 and 2011 Census years and related information published by different departments and corporations of the individual State/UT and Central government of India. The multi-temporal secondary data relating to road infrastructure at the district level have been gathered from Directorates of Census Operations and Economics and Statistics of each state/UT of India.

Indicators of Road Infrastructure:

In this study, the road infrastructure has been assessed by using following indicators:

i. Road length (km) per 100 km^2 of area

ii. Road length (km) per 10,000 of population

In order to make the data standardized, Z-score technique has been computed for above mentioned indicators by using the following formula:

$$Z = \frac{X - \vec{X}}{\sigma}$$

Where:

X represents the original value of the i^{th} variable in j time

$\vec{X}$ denotes the mean value of the i^{th} variable in j time

σ is the standard deviation from the mean value

Furthermore, to examine the extent and magnitude in the availability of road length, the districts have been gruoped into following three categories on the basis of the deviation from the mean:

Areas of Very High= Mean +>1 S.D.

Areas of High= Mean + 1 S.D.

Areas of Low= Mean – 1 S.D.

The Co-efficient of variations (C.V.) has been used to find out the inter-districts variations in road density and availability of roads per 10,000 of population.

$$C.V. = \frac{S.D.}{\vec{X}} \times 100$$

C.V: Co-efficient of variations

S.D: Standard Deviation

$\vec{X}$: Mean

Study Area

The present study focuses on the district-wise availability of road length in terms of geographical area and per size of population from 1971-2011. India is a country of huge geographic extent covering an area of 32, 87,263 km² in south of Asia. It extends from 8º 4' N to 37º 6' N latitude and 68º 7' E to 97º 25' E longitude. Thus, its latitudinal and longitudinal extent is about 30 degrees. Away from the mainland, the southernmost point of the country lies in the Andaman and

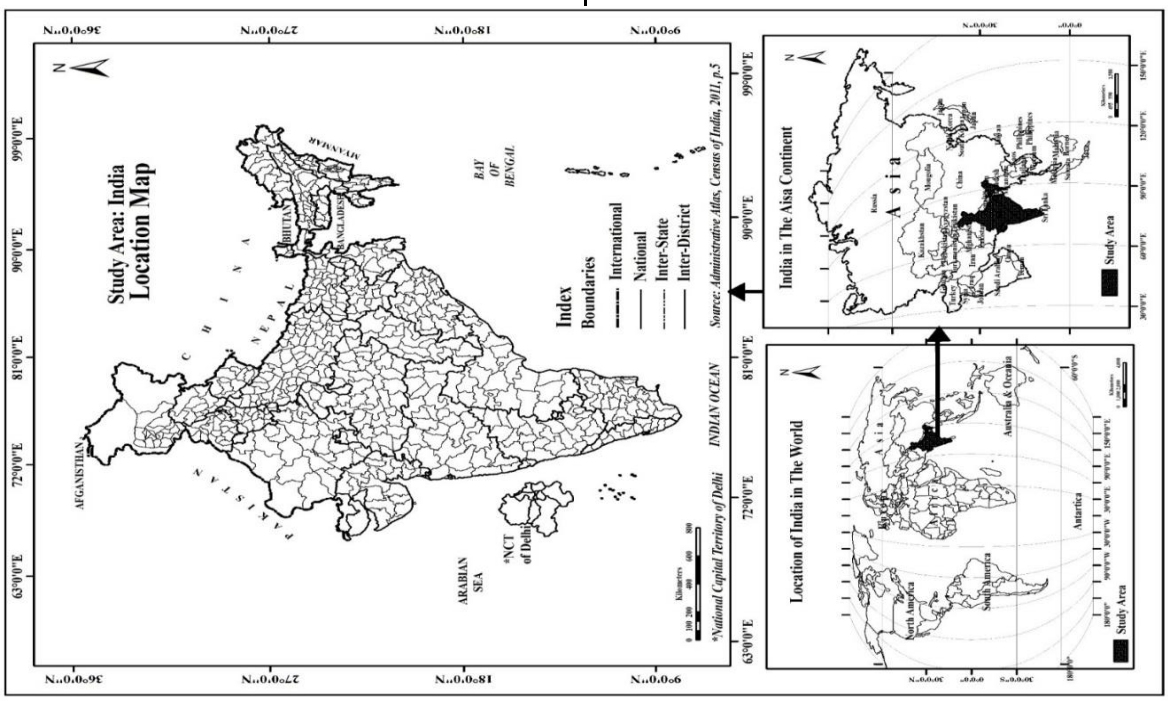

Fig. 1

Nicobar Island located at 6º 45' N latitude. Its southern half is bounded by three large water bodies viz. the Arabian sea on the west, the Bay of Bengal on the east and Indian Ocean in the south (Fig. 1). The Sri Lanka lies off the southeast coast and Maldives Islands off the southwest coast. In the north, north-east and north-west of the sub-continent lies the Himalayan ranges. India shares her boundary with Afghanistan in the north, Pakistan in the northwest, China, Nepal and Bhutan in the northeast and Bangladesh and Myanmar in the east (Fig.1).

Results and Discussion:

Road Infrastructure Development:

The country has witnessed significant improvement in road infrastructure since independence. It is evident from table 1 that the total road length in India was 3.99 lakh kms in 1951 which increased to 46.90 lakh kms in 2011. It indicates that there has been more than 15 times increase in road length between 1951 and 2011. However, this increase was not uniform over the space and time and trends vary in different indicators and different geographical scales (Table 1).

Table: 1
India: Road Infrastructure, 1951-2011

Year	Total Road length (in lakh km)	Road length (km) Per 100 sq km of Area	Road length (km) Per 10,000 population
1951	3.99	12.17	11.08
1961	5.24	15.95	11.94
1971	9.14	23.75	14.24
1981	14.85	45.19	21.74
1991	23.27	70.80	27.50
2001	33.73	102.62	32.79
2011	46.90	142.68	38.74

Source: Basic Road Statistics 2010-2011, Ministry of Road Transport and Highway, New Delhi

Trends in Road Density (100 Sq. Km of Area), 1971-2011

It is evident from table 1 and Fig. 2a that at the national level, the road length was 23.75 kms per 100 sq km in 1971 and during next two decades it increased to 70.80 km in 1991. In 2011, the road density increased further to 142.68 km per 100 sq km of area. The statistics reveals that during the last 40 years about 6 times increase has been registered in road density at the national level. It shows a notable expansion in road length in the country. However, there have been remarkable variations at the micro (district) level. With a view to examine the Spatio-temporal variations in road density, all the districts have been classified into following three classes based on the Z-score:

Areas of Very High Road Density

Fig. 2.1a shows that in 1971, there were only 8 districts (about 2.24% of total districts) having very high road density. These districts did not follow clear geographic pattern and were mainly confined to Kerala state and Union territory of Puducherry. After 20 years in 1991, the number of districts with very high road density were increased to 12 (about 2.58% of total districts). It is evident from Fig. 2.1b that majority of these districts were in Tamil Nadu state. Besides, two districts of Karnataka and union territory of Delhi, Chandigarh and Mahe district of Pondicherry also had very high road density. During next two decades (in 2011), the number of districts recording very high road density increased to 28 constituting 4.38% of total districts. It is observed from Fig 2.1c that there were two identifiable clusters of districts with very high road density. The first cluster of districts with very high road density was observed in coastal and central parts of Tamil Nadu. The second cluster of such districts was recorded in eastern and northern parts of Punjab state located in northwestern part of the study area.

Table 2.1a shows the top 20 districts by high road density in India from 1971-2011. In 1971, Chandigarh union territory ranked at the top position followed by Delhi, Mahe and Thiruvanthapuram and Ernakulam districts. The Chandigarh UT had 645.61 kms road length (Fig. 2.1a) which was 13 standard deviation greater than the mean and about 27 times higher than the national average of 23.75 kms per 100 sq km of area. In 1991, union territory of Delhi replaced the Chandigarh and stood at the top position with road density of 1461.90 kms per 100 sq km of area which was 20 times higher than the national average of 70.80 kms. The union territory of Delhi was followed by Chandigarh UT, Chennai, Bangalore and Mahe districts. It is evident from table 2.1a that in 2011, Union territory of Chandigarh enjoying the highest road density was followed by Kolkata, Lakshadweep, Kanyakumari and Sahia districts respectively. Notably, the Chandigarh UT recorded about 18 times higher road density in comparison to national average of 142.68 kms per 100 sq km of area. Even, it witnessed about 2 times high density than the

second ranking Kolkata district. The Fig. 2.1a to 2.1c and table 2.1a also brings out the fact that there has also been about 4 fold increase i.e. from 645 km/100 sq km in 1971 to 2530 km/100 sq km in 2011 in the highest road density category also. The study reveals sluggish expansion in very high road density areas with higher pace in certain pockets of Punjab state. The very high road density in certain pockets of the country has been associated with interplay of nature of terrain, economic environment and state governments initiatives together during the study period. The majority of the districts among top ranked districts having very high road density have been state capital headquarters. The coefficient of variation signifies that the variations in the road density increased between 1971 and 1991 and during 1991 and 2011 there has been significant decline in the country (Table 2.1a)

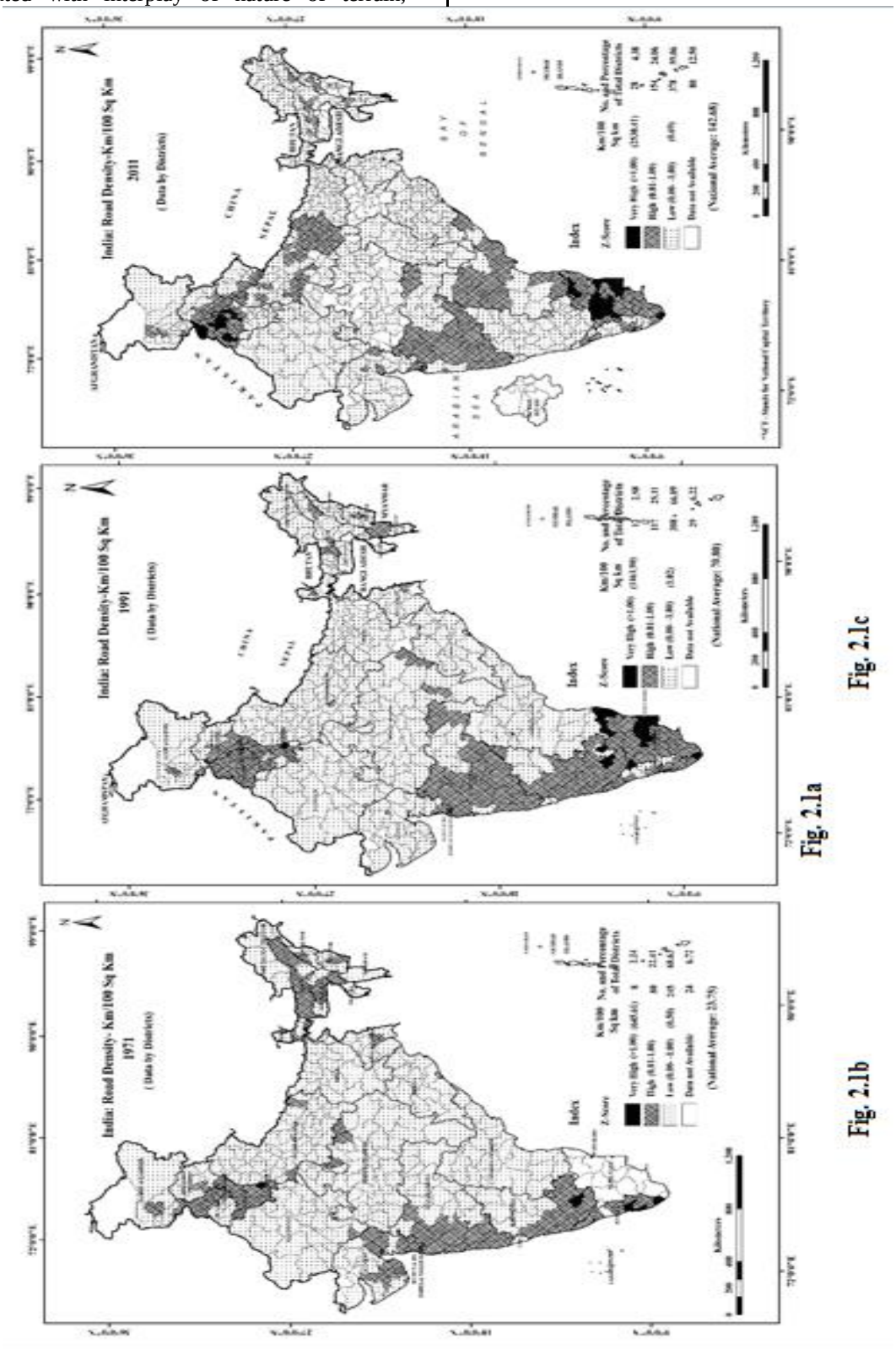

Fig. 2.1a

Fig. 2.1b

Fig. 2.1c

Table: 2.1a

India: Top 20 Districts by High Road Density, 1971-2011

Reference Years								
1971			1991			2011		
Districts	**Km/100 Sq Km**	**Z-Score**	**Districts**	**Km/100 Sq Km**	**Z- Score**	**Districts**	**Km/100 Sq Km**	**Z-Score**
Chandigarh UT	645.61	13.00	Delhi UT	1461.90	13.49	Chandigarh UT	2530.41	18.76
Delhi UT	565.07	11.32	Chandigarh UT	1245.61	11.43	Kolkata	1031.89	7.32
Mahe	174.22	3.18	Chennai	1002.59	9.12	Lakshyadweep	673.33	4.58
Thiruvananthapuram	104.38	1.72	Bangalore	353.56	2.93	Kanniyakumari	453.67	2.91
Ernakulam	90.14	1.42	Mahe	233.33	1.79	Saiha	421.44	2.66
Mandya	88.39	1.39	Kanniyakumari	217.41	1.64	Thiruvarur	416.39	2.62
Puducherry	79.12	1.19	Thanjavur	188.92	1.37	Tiruppur	397.35	2.48
Alappuzha	75.23	1.11	The Nilgiris	183.07	1.31	Chennai	367.11	2.25
Shimla	68.79	0.98	Mandya	170.71	1.19	S.B.S.Nagar	356.04	2.16
Karaikal	55.69	0.71	Chengalpattu	163.59	1.13	Ludhiana	338.39	2.03
Kozhikode	54.93	0.69	Tiruchirappalli	161.96	1.11	Thanjavur	315.46	1.85
Raigarh	52.96	0.65	North Arcot	151.78	1.01	Namakkal	312.96	1.83
Thrissur	51.38	0.62	Salem	144.37	0.94	Jalandhar	292.48	1.68
Sangli	47.15	0.53	Erode/Periyar	137.50	0.88	Cuddalore	292.25	1.68
Kollam/Quilon	45.79	0.50	Coimbatore	137.10	0.87	Mahe	286.28	1.63
Bilaspur (H.P)	45.42	0.49	Pudukkottai	133.15	0.84	Salem	272.03	1.52
The Dangs	45.28	0.49	Tirunelveli	127.67	0.78	Daman	265.28	1.47
Ambala	44.74	0.48	Sivaganga	123.83	0.75	Karur	259.69	1.43
Palakkad	42.57	0.43	Cuddalore	117.17	0.68	Erode	247.86	1.34
Ratnagiri	40.51	0.39	Imphal	113.73	0.65	Nagapattinam	244.65	1.31
Mean $(\overline{X})$	**21.77**		**Mean $(\overline{X})$**	**45.26**		**Mean $(\overline{X})$**	**72.81**	
S.D. (σ)	**48.01**		**S.D. (σ)**	**105.01**		**S.D. (σ)**	**131.00**	
C.V. (%)	**220.53**		**C.V. (%)**	**232.02**		**C.V. (%)**	**179.92**	

Source: Compiled by Authors from Statistical Abstracts of States and Union Territories of India

Areas of High Road Density

The Fig. 2.1a portraits that in 1971, there were about 22% of total districts recording high road density. The study reveals that districts corresponding to high road density tended to cluster in national space and these clusters cut across state boundaries. It has been observed that majority of these districts constituted a continuous belt of states including Kerala, Mysore, Maharashtra and Gujarat. Besides, almost entire Haryana, Punjab and some districts of Assam, Meghalaya and Manipur also recorded high road density. The study indicates that the coastal location, availability of plain terrain, industrial and agricultural development of these districts were the factors responsible for the rapid expansion of the roads in early 1970s. In 1991, there were about one fourth of total districts enjoying high road density. The Fig. 2.1b shows that peninsular plateau of India and north western part of the Gangetic plain recorded high road density. In peninsular plateau, almost entire Tamil Nadu, coastal and central parts of Kerala, Karnataka and Maharashtra recorded high road density in 1991. The Fig. 2.1b shows that high road density was observed in majority of districts of Punjab and Haryana. A few individual districts scattered in central and north eastern part of India also exhibited high road density. The high road density in parts of peninsular plateau and Punjab plains of India in 1990s was due to relatively high per capita income, rich industrial and agricultural base and comparatively high expenditure on transport sector in respective states. In 2011, the number of districts with high road density further increased to 154 however the percentage share remained almost stagnant i.e. about one-fourth of the total districts. The Fig. 2.1c demonstrates that identifiable clusters of district with high road density were observed in peninsular plateau and northern plain of India. In peninsular region, the central and coastal districts of Maharashtra and northern part of Andhra Pradesh witnessed high road density. Besides, almost entire Tamil Nadu, and a few districts of Kerala also enjoyed high road density in 2011. Notably, in 2011, whole of Karnataka state relegated from high category to low category of road density because of slow pace of road expansion in relation to other parts of the study area. The statistical utility of Z-score computed for all districts of the country corroborates this fact. A cluster of districts with high road density was observed in Punjab, the Shiwalik part of Himachal Pradesh and eastern part of Uttar Pradesh (Fig. 2.1c).

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Areas of Low Road Density

The study shows a remarkable progress registered in road expansion in India during study period. But, still majority of the districts of the country have poor or low road density. Fig. 2.1a shows that in 1971, about two-third of districts (68%) of the country exhibited low road density having 0 to -1 standard score. The Fig. 2.1a illustrates that entire Rajasthan, Uttar Pradesh, Bihar, West Bengal, Odisha, Andhra Pradesh, Madhya Pradesh, Gujarat, Himachal Pradesh, Jammu & Kashmir and eastern part of Maharashtra had poor road connectivity in 1970s. The majority of the districts of northeastern states also had witnessed poor road density. During next 20 years, in 1991, the situation didn't improve a lot in this category as about 66% of total districts had poor road density. The Fig. 2.1b depicts almost similar road density pattern in 1991 and the central and eastern India have witnessed poor road density. In 1991, majority of the districts of Assam slided from high to low category of road density because of slow pace of development in relation with other parts of the study area. It happens because road expansion took place at faster rate in other districts of the country than north eastern India. The standard score doesn't only the departure from the national average but also the pace of relative road expansion. The Fig. 2.1c portrays that in 2011, still an overwhelming majority about 59% of total districts reported poor or low road density in the country. The hilly and mountainous region, desert and marshy areas and northern and eastern part of peninsular plateau have registered poor or low road density.

Table 2.1b represents the bottom 20 districts of the country suffering from very poor road connectivity between 1971-2011. In 1971, Leh district had the least road density. The other districts in decreasing order of poor road density were Bathinda, Lohit, Subansiri, Siang, Koraput and Lahual & Spiti respectively. Even in 1991, Leh district continued to suffer from low connectivity of surface roads followed by Banda, Hamirpur (Uttar Pradesh) and Dibang Valley districts. It is evident from table 2.1b that in 2011, Katni district ranked at the bottom place of road density followed by Betul, Leh and Sehore districts. The bottom rank of Katni, Betul and She districts could be attributed due to statistical fallacy. The study exhibits that the dissected topography, criss-cross streams and presence of sandy tract in desert areas and dense forest cover prevented the expansion and construction of road in these districts

Table: 2.1b
India: Bottom 20 Districts by Road Density, 1971-2011

Reference Years								
1971			1991			2011		
Districts	Km/100 Sq Km	Z-Score	Districts	Km/100 Sq Km	Z-Score	Districts	Km/100 Sq Km	Z-Score
Leh	0.50	-0.44	Leh	1.02	-0.42	Katni	0.69	-0.55
Bathinda	1.08	-0.43	Banda	2.33	-0.41	Betul	2.08	-0.54
Lohit	1.69	-0.42	Hamirpur	2.51	-0.41	Leh	2.08	-0.54
Subansiri	2.82	-0.39	Dibang Valley	2.67	-0.41	Sehore	2.90	-0.53
Siang	3.17	-0.39	Tuensang	2.93	-0.40	Kishtwar	3.37	-0.53
Koraput	3.36	-0.38	Lalitpur	3.50	-0.40	Bastar	3.66	-0.53
Lahaul-Spiti	3.86	-0.37	Changlang	4.21	-0.39	Dibang Valley	3.82	-0.53
Doda	4.34	-0.36	Kargil	4.40	-0.39	Dakshin Bastar	3.94	-0.53
Kameng	4.35	-0.36	Upper Subansiri	4.54	-0.39	Narayanpur	4.09	-0.52
Sikkim	4.40	-0.36	Jhansi	4.57	-0.39	Bijapur	5.11	-0.52
Bikaner	4.44	-0.36	Kalahandi	4.61	-0.39	Bhopal	5.37	-0.51
Kalahandi	4.46	-0.36	West Kameng	4.64	-0.39	Surguja	6.06	-0.51
Keonjhar	4.50	-0.36	Koraput	4.71	-0.39	Malkangiri	6.10	-0.51
Chamoli	4.55	-0.36	Phek	4.74	-0.39	Jashpur	6.35	-0.51
Surguja	4.82	-0.35	Lower Subansiri	5.10	-0.38	Anjaw	6.59	-0.51
Uttarkashi	5.03	-0.35	Dhenkanal	5.31	-0.38	Kurung Kumey	6.62	-0.51
Kachchh	5.11	-0.35	West Siang	5.71	-0.38	Kargil	6.96	-0.50
Dhenkanal	5.13	-0.35	Jaisalmer	5.86	-0.38	Nabarangpur	6.99	-0.50
Jaisalmer	5.14	-0.35	Palamu	5.94	-0.38	Uttar Bastar	7.44	-0.50
Warangal	5.25	-0.34	Doda	5.96	-0.38	Mumbai	8.13	-0.49

Source: Compiled by Authors from Statistical Abstracts of States and Union Territories of India

Trends in Road Length (km/10,000 of Population), 1971-2011

The study represents that the average road length in India per 10,000 of population was 14.24 kms in 1971, which doubled in next 20 years (27.75 kms in 1991) and further increased to 38.14 kms in 2011. Thus, there has been more than two and half times increase in road length per 10,000 of population between 1971 and 2011. The spatio-temporal variations in the road length per size of population at the district level have been discussed into following three categories based on Z-score:

Areas of Very High Length of Road (Km)/10,000 of Population

Fig. 3.1a illustrates that in 1971, about 6.72% districts (24 districts) had very high road length per 10,000 of population which increased to about 7% (32 districts) in 1991. The number and share of such districts sharply decreased to 19 and 3% of total districts in 2011 (Fig. 3.2c). The study reveals that in all these districts the road length per 10,000 of population was very high with standard score more than 1 from the mean. Fig. 3.1a portrays that a contiguous belt covering almost entire Arunachal Pradesh, Nagaland, Mizoram and Meghalaya had very high road density per size of population in 1971. The same pattern was also observed in Leh and Lahaul & Spiti districts in western Himalaya and the desert districts namely Jaiselmer and Barmer in Rajasthan state. The study point out that the low density of population and dispersed pattern of human settlements connecting districts headquarters with rural roads resulted into very high road network per size of population. In 1991, the mountainous districts of the Himalayas continue to have very high road length per size of population. Besides, few individual districts of Karnataka and Tamil Nadu also witnessed very high availability of roads per 10,000 of population (Fig. 3.1b). In 2011, the areas under very high road length per size of population category decreased because of fast increase in population and relatively slow pace of road development in Himalayan states. However, the study reveals that the Lahual-Spiti, Leh and few districts of Arunachal Pradesh continues to enjoy very high availability of roads length per 10,000 of population.

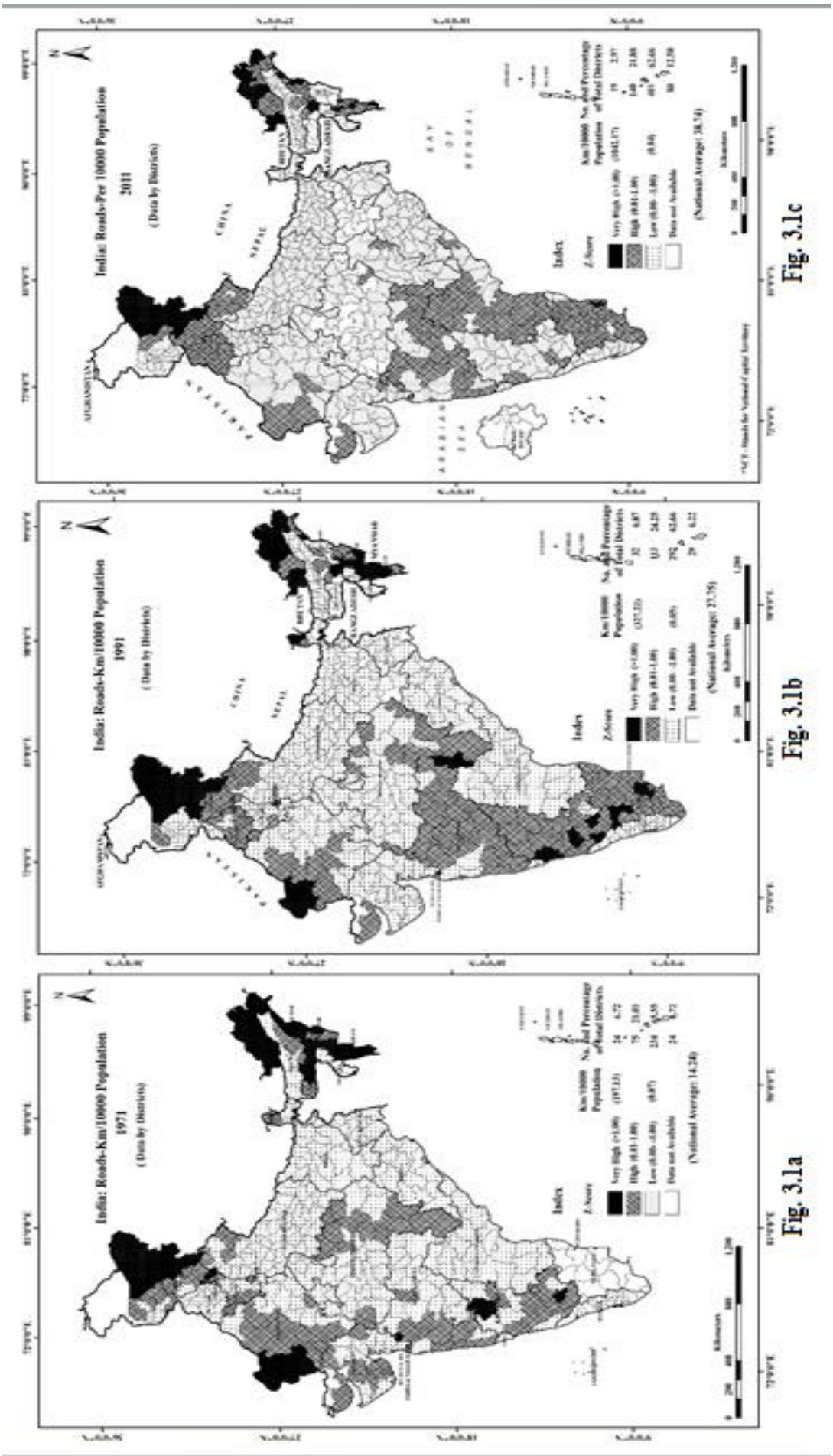

Fig. 3.1a

Fig. 3.1b

Fig. 3.1c

Table: 3.1a

India: Top 20 Districts by Road Length per Size of Population, 1971-2011

Reference Years								
1971			1991			2011		
Districts	Km/10000 Population	Z-Score	Districts	Km/10000 Population	Z-Score	Districts	Km/10000 Population	Z-Score
Lahaul-Spiti	197.13	9.28	Lahaul-Spiti	327.22	11.55	Saiha	1042.17	18.66
Jaisalmer	118.25	5.27	Tawang	308.96	10.87	Dibang Valley	435.71	7.55
Kinnaur	116.58	5.18	North Sikkim	153.97	5.08	Lahaul-Spiti	385.88	6.64
Manipur West	115.50	5.13	Kinnaur	140.03	4.56	Tawang	248.22	4.12
Dima Hasao	100.33	4.36	Leh -Ladakh	94.33	2.86	Anjaw	192.82	3.10
Manipur East	89.67	3.81	Dibang Valley	80.63	2.35	Kolasib	180.29	2.87
Tirap	87.51	3.70	Tamenglong	79.92	2.32	Upper Siang	179.39	2.86
The Dangs	80.90	3.37	Dima Hasao	79.38	2.30	Serchhip	153.28	2.38
Mokokchung	79.29	3.29	West Siang	76.27	2.18	West Kameng	129.10	1.94
Siang	69.56	2.79	Kargil	76.23	2.18	Leh -Ladakh	129.08	1.93
Kameng	69.42	2.78	Chamba	67.97	1.87	Kinnaur	119.23	1.75
Lohit	65.86	2.60	The Nilgiris	65.70	1.79	Kiphire	117.43	1.72
Tuensang	62.31	2.42	East Siang	65.49	1.78	West Siang	112.43	1.63
Kohima	55.54	2.08	Jaisalmer	65.37	1.78	Upper Subansiri	96.89	1.35
Shimla	42.88	1.43	Lohit	64.73	1.75	Tirap	94.74	1.31
Manipur South	40.13	1.29	Chikmagalur	64.15	1.73	Longleng	87.16	1.17
Leh	39.32	1.25	Upper Subansiri	63.69	1.72	Dima Hasao	85.75	1.14
United Khasi & Jaintia Hill	38.40	1.21	West Kameng	61.04	1.62	Tuensang	85.71	1.14
Mandya	37.99	1.18	East Kameng	58.02	1.50	Thiruvarur	78.29	1.00
Mizoram	37.31	1.15	East Sikkim	57.05	1.47	Peren	77.82	1.00
Mean $(\overline{X})$	**14.70**		**Mean $(\overline{X})$**	**17.72**		**Mean $(\overline{X})$**	**23.44**	
S.D. (σ)	**19.66**		**S.D. (σ)**	**26.80**		**S.D. (σ)**	**54.60**	
C.V. (%)	**133.74**		**C.V. (%)**	**151.24**		**C.V. (%)**	**232.94**	

Source: Compiled by Authors from Statistical Abstracts of States and Union Territories of India

The table 3.1a shows the top twenty districts by road length per 10,000 of population in study area from 1971-2011. It is evident from table 3.1a that there were remarkable variations in road length in terms of population. In 1971, Lahaul-Spiti district with road length of 197.13 kms per 10,000 of population ranked at the top followed by Jaislemer (118.25), Kinnaur (116.58) and Manipur West (115.50 kms) districts. In 1991, Lahaul-Spiti district maintained its top position followed by Tawang, North Sikkim, Kinnaur and Leh districts respectively. Notably, in 2011, Saiha district replaced the Lahaul-Spiti and occupied top position followed by Dibang valley, Lahual-Spiti and Tawang districts. The study reveals notable inter-district disparities in the availability of roads per 10,000 of population. The study indicated that in 1971, the road length vis-a-vis population size was about 14 times greater than the national average in top ranked Lahual-Spiti district and even 2 times more than the second ranked i.e. Jaiselmer district. In 1991 it was 12 times greater than the national average, however closely followed by second rank Tawang district. The study exhibits that the top ranked Saiha district in 2011 has witnessed 27 times high road length (kms) per 10,000 of population than national average of 38.14 and more than 2 times higher than the second rank Dibang Valley district. The coefficient of variation (table 3.1a) shows that the inter-district disparities in road length per 10,000 of population has increased during 1971 to 2011 because of varying pace of road development and population growth among different parts of the study area.

Areas of High Road Length (km)/10,000 of Population

In 1971, there were 21% districts with high road length which increased to 24% in 1991 and slightly decreased to 22% in 2011. The study shows that about one-fifth of total districts had the high road length per size of population during all the reference periods. The Fig. 3.1a illustrates that the areas adjoining the very high road length regions have high road length as per population norm. In 1971, a narrow belt running from north-western part of Jammu & Kashmir state to eastern part of Uttar Pradesh hills exhibited high road length per 10,000 of population. Notably, large concentration of districts with high road length per size of population was observed in central and western part of Rajasthan desert

Table: 3.1b
India: Bottom 20 Districts by Road Length per Size of Population, 1971-2011

Reference Years								
1971			1991			2011		
Districts	Km/10000 Population	Z-Score	Districts	Km/10000 Population	Z-Score	Districts	Km/10000 Population	Z-Score
Kolkata	0.07	-0.74	Mumbai	0.05	-0.66	Mumbai	0.04	-0.43
Mumbai	0.07	-0.74	Hyderabad	0.55	-0.64	Katni	0.26	-0.42
Bathinda	0.58	-0.72	Samastipur	0.73	-0.63	Hyderabad	0.54	-0.42
Varanasi	1.41	-0.68	Allahabad	0.83	-0.63	Bhopal	0.63	-0.42
Haora	1.47	-0.67	Banda	0.95	-0.63	Bangalore	0.96	-0.41
Muzaffarpur	2.02	-0.64	Vaishali	1.08	-0.62	Purba Champaran	1.01	-0.41
Saran	2.12	-0.64	Hamirpur	1.23	-0.62	Sheohar	1.05	-0.41
Saharsa	2.14	-0.64	Katihar	1.30	-0.61	Sitamarhi	1.12	-0.41
Cuttack	2.17	-0.64	Sitamarhi	1.36	-0.61	Munger	1.12	-0.41
Twenty Four Parganas	2.22	-0.63	Purba Champaran	1.41	-0.61	Haora	1.14	-0.41
Bareilly	2.31	-0.63	Dhanbad	1.43	-0.61	Begusarai	1.14	-0.41
Balasore	2.37	-0.63	Haora	1.44	-0.61	Darbhanga	1.15	-0.41
Darbhanga	2.37	-0.63	Darbhanga	1.53	-0.60	Paschim Champaran	1.18	-0.41
Kanpur Dehat	2.39	-0.63	Fatehpur	1.54	-0.60	Vaishali	1.19	-0.41
Gaya	2.46	-0.62	Gopalgani	1.55	-0.60	Saran	1.22	-0.41
Badaun	2.54	-0.62	Jhansi	1.61	-0.60	Samastipur	1.27	-0.41
Farrukhabad	2.55	-0.62	Saran	1.61	-0.60	Betul	1.33	-0.41
Dhanbad	2.60	-0.62	Begusarai	1.63	-0.60	Muzaffarpur	1.37	-0.40
Purba Champaran	2.64	-0.61	Pratapgarh	1.70	-0.60	Chennai	1.37	-0.40
Munger	2.65	-0.61	Paschim Champaran	1.71	-0.60	N. Twenty Four Parganas	1.39	-0.40

Source: Compiled by Authors from Statistical Abstracts of States and Union Territories of India

Fig. 3.1a represents that another pockets of districts was found in north eastern Madhya Pradesh. The coastal and central parts of Maharashtra and Karnataka were also registered high road length (kms) per 10,000 of population. In 1991, there has been expansion of the area under high road length category in relation to population. A large part of peninsular plateau covering Maharashtra, Karnataka, Tamil Nadu and extreme southern part of Madhya Pradesh exhibited high road length (kms) per 10,000 of population. A small cluster of districts was found in south western part of Rajasthan. Fig. 3.1b shows that almost entire Himachal Pradesh, hill areas of Uttar Pradesh and Punjab also recorded high road length per size of population. The study observed that high road length in mountainous areas of Himachal Pradesh and Uttar Pradesh hills was due to relatively low density of population along with construction of new village roads while the high road length in southern parts of the country resulted due to rapid expansion of roads between 1971-1991. In 2011, the areas with high road length were concentrated in small pockets such as northern and southern parts of the study area. Majority of the districts of the Andhra Pradesh state witnessed more construction of new roads comparison to other states or districts and moved from low to high road length category (Fig. 3.1c). The standard score indicates that during early 1970s, the pace of road development was more in coastal and western part of India. During next 20 years i.e. 1991, it got momentum in different districts of southern states mainly Tamil Nadu, Maharashtra and Karnataka. It is evident from Fig. 3.1c that in 2011, the central and eastern part of Maharashtra, Andhra Pradesh and Tamil Nadu has observed relatively higher pace of development in road length (km) per size of population.

Areas of Low Road Length (km)/10,000 of Population

The proportion of the districts with low road length (km) per 10,000 of population has shown almost similar pattern during all the reference periods (Fig. 3.1a to 3.1c). In 1971, about two-third of the country was under low road length. This proportion decreased marginally to 62% in 1991 and 2011. As evident from Fig. 3.1a that low road length km per 10,000 of population was observed in densely populated northern plains of India which including Uttar Pradesh, Bihar, Punjab and West Bengal. In addition, coastal and central states of India also recorded low road length in relation to population. In 1991, a similar contiguous belt running from Haryana and Rajasthan in west to West Bengal and Assam in the east registered low road length per size of population. In addition, the coastal states of India namely Odisha, Andhra Pradesh, Kerala and Gujarat were also in low road length category as per 10,000 of population norm. In 2011, a vast tract of the country has witnessed low road length (km) per 10,000 of population (Fig. 3.1c). The study demonstrates that almost entire northern plain (except Punjab) and northern & eastern parts of peninsular plateau have registered low road length per size of population. The study points out that the

pace of road development in majority of these districts was not at par with other districts and considerably higher population pressure resulted into low road length per size of population. Further, low per capita income, inequality in resource allocation and low social development of these states could be the cause of slow pace of development of roads per size of population.

It is evident from the table 3.1b that in 1971, Kolkata district was at the bottom in the context of road length per size of population. The other districts in descending order were Mumbai, Bathinda and Varanasi respectively. In 1991 and 2011 Mumbai district maintained with bottom position followed by Hyderabad, Samastipur and Allahabad in 1991 and Katni, Hyderabad and Bhopal districts in 2011. It is found that population generally move towards developed areas which slows the development process by increasing social costs and pressure on existing infrastructural facilities. The same situation could be experienced in Kolkata, Mumbai, Hyderabad, Allahabad, Bengaluru and Chennai districts.

Concluding Remarks:

It is evident from the foregoing discussion that there has been remarkable increase in road length both in terms of geographical area and availability of roads per size of population during the three reference periods. The study reveals that the road length has increased from 23.75 kms per 100 sq km of area in 1971 to 142.68 km per 100 sq km in 2011. It indicates about six times increase in road density during 40 years. Similarly, the availability of roads per size of population also increased from 14.24 km in 1971 to 38.14 km in 2011. The study reveals both inter-regional and inter-districts disparities in road infrastructure in India. The coastal and northern plains of India are sufficiently endowed with the road infrastructure whereas the mountainous areas, desert and peninsular parts are still lagging behind in road infrastructure. The study brings out that the very high road density have been observed in those districts which are state capital headquarters. The study also exhibits the changing pattern of road density which could be attributed to faster expansion of roads in other parts/districts of the country.

The availability of roads per 10,000 of population shows that almost entire Arunachal Pradesh, Nagaland, Mizoram, Meghalaya in Himalayan region and desert part of Rajasthan state in western part have witnessed very high road density per size of population. In these areas, the low density of population and dispersed pattern of human settlements connecting districts headquarters with rural roads resulted into very high road network per size of population. Furthermore, the study demonstrates that almost entire northern plain (except Punjab) and northern & eastern parts of peninsular plateau have registered low road length per size of population. The study points out that the pace of road development in majority of these districts was not at par with other districts and considerably higher population pressure resulted into low road length per size of population. Besides, low per capita income, inequality in resource allocation and low social development of these states could be the cause of slow pace of development of roads per size of population. The coefficient of variation also signifies that the variations in the road density increased between 1971 and 1991 and during 1991 and 2011 there has been remarkable decline in the country. However, the inter-district disparities in road length per size of population has increased during 1971 to 2011 because of varying pace of road development and population growth among different parts of the study area. The study stressed that the widening inter-district disparities in level of road infrastructure both in terms of geographical area and per size of population needs closer attention of development planners and policy makers.

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