Physical infrastructure: Spatial differences and magnitude of development in India

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Abstract

In present paper the level of physical infrastructural development has been examined with reference to three dimensions namely transport, communication and agriculture infrastructure in India. The standardised index has been computed by using principal components analysis. The study shows that the north-western part comprising of Punjab, Haryana and western part of Uttar Pradesh has witnessed very high and high level of physical infrastructural development because of low density of population and high factor score for infrastructural facilities like road length, communication facilities namely post offices, telephone exchanges and higher proportion of net irrigated area to net sown area. Likewise, the peninsular and central parts of the country have witnessed low level of physical infrastructural development because of undulating and dissected topography, high pressure of population on existing facilities, poor socio-economic conditions, lack of irrigation facilities and dense forest cover together impeded the development of transport, communication and agricultural facilities.

Keywords: Physical infrastructure, principal components analysis, standardised index, India

Introduction

Infrastructure constitutes the fulcrum of economic and social development of any region. Infrastructures provide the foundation for virtually all modern day economic activities, constitute a major economic sector and contribute importantly in raising the living standards and quality of life (Steven and Schieb, 2007). The physical and socio-economic infrastructure has direct impact on the country's economic growth and it indirectly affects the social development. The development of economic infrastructure in developed countries has significantly contributed to the increase in production and productivity that have directly resulted in growth of gross national product and per capita income. High income return has encouraged higher expenditure on development of education and health which have its bearing on the human resource development and human welfare (Shah and Patel, 2006).

In India, the awareness about the importance of infrastructure came very late when it was realized that infrastructure in country is highly inadequate compared to country's needs especially in the fields of transport, power, science and technology without which the country cannot reap the benefit of economic liberalization. Another distinctive feature is that the existing infrastructure is both underutilized and improperly used. The visible signs of shortfalls in capacity and inefficiencies include increasingly congested roads, power failures, long waiting list for installations of telephones and shortage of drinking water. The general picture which emerges is that not only the demand for infrastructural facilities and services continues to outpace supply but also the quality of existing supply is poor. This widening gap between demand and supply of infrastructure also raises the question concerning the sustainability of economic growth in future (Economic Survey, 1997).

The physical infrastructure is the instrument for the formation of the bases and foundation for origin, generation, stimulation, acceleration and continuous production of economic activities and diffusion, distribution and marketing ideas, researches, inventions, technology and production. It also influences directly or indirectly the process of modernization and transformation of society (Verma and Shahi, 1988). Rosenstein observed that physical infrastructure refers to the social overhead capital comprising of all those basic industries like power, transport or communications which must precede the more quickly yielding directly productive investments and constitute the framework or infrastructure and the overhead cost of the economy as a whole (Joshi, 1990). Physical infrastructure is capital intensive as this sector requires huge capital expenditure in some cases i.e. port, power, irrigation, transportation etc. (Bagchi, 2010).

Objectives of the Study

The present study aims at realising the following two objectives:

a. To study the level of physical infrastructure in terms of roads, communication and agricultural facilities.

b. To identify the magnitude of variations in the level of infrastructural development in India.

Data Base and Methods

The present study has been undertaken to examine the spatial variations in level of physical infrastructural development at district level in India during 1971, 1991 and 2011 i.e. at an interval of 20 years. The 1971 has been taken as base year for study because of non-availability of the data of certain indicators of physical infrastructural development at district level prior to 1971. The inter-district variations in physical infrastructural development has been examined with respect to three above mentioned reference years as per the changing administrative units.

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 each individual state/UT and central government of India. The multi-temporal secondary data relating to indices of physical infrastructural development and other related information at the district level have been gathered from directorate of census operations, district census handbooks, planning department, directorate of economics and statistics, directorate of land records and department of health and family welfare of each state/UT of India. The secondary data collection from all states and union territories of the country has been the most herculean task in the present study. The data collection exercise from all the states and UT headquarters was consummated in two phases. The first phase began in month of January, 2015 and completed in March, 2015. The second leg of secondary data collection was completed during April and May, 2015.

The physical infrastructure has been examined with reference to following 3 components, each having varying numbers of indicators:

Transport Infrastructure

i. Road length (km) per 100 sq kmof area
ii. Road length (km) per 10000 of population
iii. Length of national highways (km) per 100 sq kmof area
iv. Length of national highways (km) per 10000 of population
v. No. of registered motor vehicles per 100 sq km of area
vi. No. of registered motor vehicles per 10000 of population

Communication Infrastructure

i. No. of post offices per 100 sq km of area

ii. No. of post offices per 10000 of population

iii. No. of telephone exchanges per 100 sq km of area

iv. No. of telephone exchanges per 10000 of population

Agricultural Infrastructure

i. Net sown area (ha) per 100000 of Population

ii. Net sown area to total geographical area (%)

iii. Net irrigated area to net sown area (%)

iv. Cropping intensity (%)

v. Irrigation intensity (%)

vi. Wooden and iron ploughs per1000 ha of net sown area

vii. No. of tractors 1000 ha of net sown area

In all, 17 indicators have been chosen to examine the physical infrastructure development in the study area. Z-score technique has been used for the standardisation of data for all the variables by using the following formula:

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

Where: X represents the original value of the ith variable in j time

$\overline{X}$ denotes the mean value of the ith variable in j time

σ is the standard deviation from the mean value

The development (standardised) index of physical infrastructure has been constructed by using principal components analysis (PCA) method developed by Hotelling (1933) and used by many social scientists including geographers in multivariate statistical analysis. The principal components method of factor analysis has been used to reduce the dimensions of variables that adequately summarize the information contained in the set of original variables into a smaller group of factors with minimum loss of information. The appropriateness of principal components analysis (PCA) technique has been assessed based on standardisation of variables, provision of visual analysis of correlation matrix for all the variables and Kasier-Meyer-Olkin (KMO), a measure of data adequacy. The Z-Score formula has been used to standardise the variables available in different units of measurement. As per visual analysis of correlation matrix, variables having correlation of 0.3 or greater have been considered for the present study. The KMO measure has been more than 0.5 in all cases which indicates the appropriateness of the use of PCA.

In present study, the principal components have been extracted and retained based on four key considerations i.e. i) eigen value more than 1.0, ii) scree plot information, iii) 80 per cent of variance explained and iv) factor loadings greater than 0.50 in rotated components matrix in the present study.

Given the fact that this importance of the factors in measuring infrastructural development index used for mapping and interpretation of individual components of the infrastructure is not uniform. Therefore, for showing the overall level of physical, social and combined infrastructural development, initially, a non-standardised index (NSI) was developed for each district. The NSI is based on the proportion of percentages obtained as weights on the factor score coefficients.

A non-standardized index (NSI) was developed for each district by using the following formula:

NSI = (% variance of factor 1/total variance) (factor 1 score) + (% variance of factor 2 /total variance) (factor 2 score) + (% variance of factor n/total variance) (factor n score).

This index measures the development of one district relative to the other on a linear scale. The value of the index can be positive or negative, making it difficult to interpret. Therefore, a Standardized Index (SI) was developed, the value of which can range from 0 to 100, using the following formula:

$$Standarised\ Index = \frac{(\text{NSI of District 1} - \text{Min NSI})}{(MaxNSI - MinNSI)} \times 100$$

The scores were later reversed to make the interpretation easier; the higher the value, the better the infrastructural development of an area. Further, the Standardised Index (SI) showing the level of infrastructural development at the district level has been divided into following five categories:

Standardised Index	Level of Development
More than Mean + 2 S.D	Very High
Mean + 1 S.D to Mean + 2 S.D.	High
Mean to Mean + 1 S.D.	Moderate
Mean -1 S.D to Mean	Low
Less than Mean - 1 S.D	Very Low

The inter-district variations have been shown with the help of choropleth maps prepared on GIS platform for all the three reference periods.

Results and Discussions

The development pattern of physical infrastructure between 1971 and 2011 may be examined with reference to following five categories based on standardised index:

Areas with Very High Physical Infrastructural Development

The figs. 1 to 3 illustrate that there has been fluctuation in proportion of area and population covered in very high level of physical infrastructural development category in study area. In 1971, only nine districts (about 3%) of total districts have witnessed very high level of physical infrastructural development which increased to 14 in 1991. The number of such districts slightly decreased to 11 in 2011. Figs.1 to 3 portray that about 1% of the total area of the country has exhibited very high level of physical infrastructural development throughout the study period. However, the proportion of population varied from 3% in 1971 to 4% in 1991. The study shows that in 2011, about 1% of total population of the country was recorded in highly developed category. It signifies that the pace of development of infrastructure is very low than growth of population in the country. It is evident from table 1that in 1971, Delhi district ranked at the top position in development of physical infrastructure followed by Chandigarh, Mumbai, Mahe, Manipur West, Lahaul-Spiti and Yanam districts. In 1991, Chandigarh district replaced the Delhi and occupied top position in the level of physical infrastructural development. The other districts in descending order were Delhi, Hyderabad, Chennai and Lahual-Spiti. The study reveals that in 2011, Chandigarh UT continued with very high level of physical infrastructure followed by Saiha, Lahaul-Spiti, Chennai, Kolsib, Solan and Panchkula districts. The study reveals that very high level of physical infrastructural development in these districts could be attributed to the benefit of state capital, functioning as nuclei of development resulting into early start of development process and better socio-economic background. The Lahaul-Spiti, Saiha and Kolasib districts exhibited very high physical infrastructural development because of very low density of population and high factor score for infrastructural facilities like road length, communication facilities namely post offices, telephone exchanges, share of net irrigated area to net sown area. The study points out that all the districts were different in the context of individual indicators or sectoral development. Chandigarh district symptomatic of well-developed transport and communication facilities ranked at the top despite the fact that it had poor agricultural wherewithal.

Areas with High Level of Physical Infrastructural Development

The study reveals that areas with high level of physical infrastructural development comprised of 20 districts in 1971 which increased to 33 in 1991 and 37 in 2011. However, in 1971, about 4% of geographical area was highly developed in physical infrastructure (Fig. 1) which increased to 6% in 1991. The share of developed area decreased to 3% in 2011.It is evident from fig. 3 exhibits that the spatial distribution of districts with high level of physical infrastructural development remained almost same in the areas mainly Punjab and eastern part of Haryana in 2011. The study reveals that there are some districts that have shifted from one category to another because of their being on the margin of scaling cut-off points. As evident from fig. 3 most of the districts of Himachal Pradesh registered moderate level of physical infrastructural development.It has been discovered that proportion of population in high level of physical infrastructural development experienced fluctuating proportion of population from 4.73% in 1971 to about 4% in 2011 it clearly signifies that pace of expansion of physical facilities remained slow than population increase during the study period. The study reveals that areas witnessing high level of physical infrastructural development mainly included

whole of Himachal Pradesh, Punjab, northern parts of Haryana and eastern part of Jammu & Kashmir. Fig. 2 also portrait that, a small patches of districts with high level of physical infrastructural development were recorded in western part of Uttar Pradesh (north region), southwestern part of Karnataka (south region) and northern part of Manipur (northeast region).

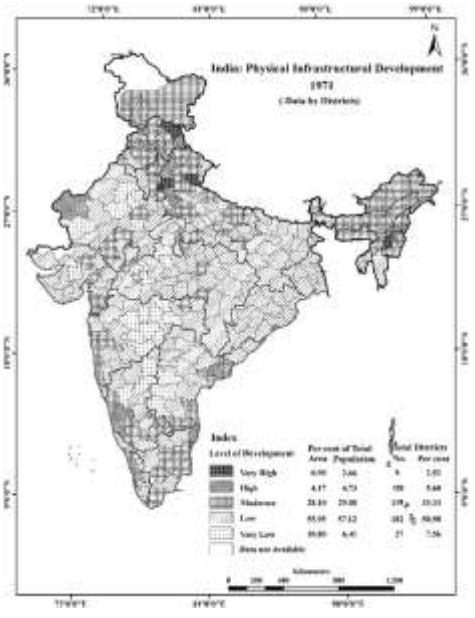

Fig. 1: Physical infrastructural development in India, 1971

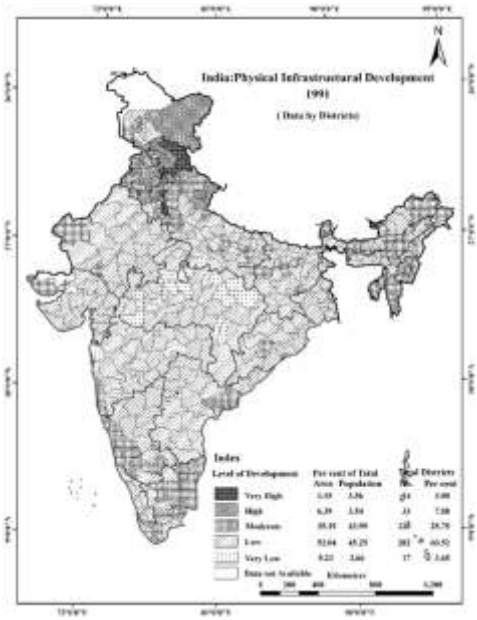

Fig. 2: Physical infrastructural development in India, 1991

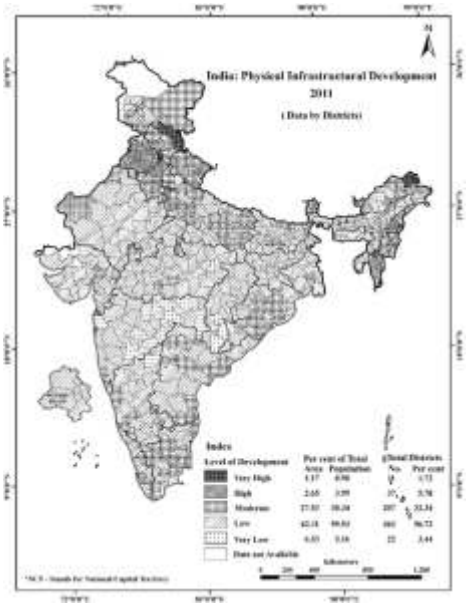

Fig. 3: Physical infrastructural development in India, 2011

Table 1: Top 20 districts by physical infrastructural development in India, 1971-2011

Reference Years					
1971		**1991**		**2011**	
Districts	**Standardised Index**	**Districts**	**Standardised Index**	**Districts**	**Standardised Index**
Delhi	100.00	Chandigarh	100.00	Chandigarh	100.00
Chandigarh	93.62	Delhi	72.47	Saiha	45.87
Mumbai	91.49	Hyderabad	70.32	Lahaul-Spiti	39.13
Mahe	78.60	Chennai	66.95	Chennai	34.67
Manipur West	61.59	Lahaul-Spiti	57.19	Kolasib	27.09
Lahaul-Spiti	57.10	Kinnaur	50.97	Solan	26.95
Yanam	56.36	Yanam	40.48	Panchkula	24.56
Nainital	51.54	Mumbai	38.49	Kinnaur	23.50
Meerut	48.36	Shimla	37.38	Kiphire	22.98
Kinnaur	43.93	Sonipat	37.29	Dibang Valley	20.72
Jaisalmer	43.93	Solan	35.85	Ghaziabad	20.58
D. Kannada	42.41	Hamirpur	35.32	S.B.S.Nagar	19.91
Bulandshahar	41.74	Tawang	34.73	Serchhip	19.81
Jammu	40.88	Karnal	31.95	Kolkata	19.79
Muzaffarnagar	39.38	Mahe	30.66	Jalandhar	19.20
Manipur North	39.11	Mandi	30.56	Ludhiana	19.17
Thrissur	38.99	Kurukshetra	30.26	Faridkot	19.15
Shimoga	38.49	Bilaspur	29.85	Kapurthala	18.97
Saharanpur	38.29	Sirmaur	29.27	Patiala	18.91
DimaHasao	38.13	Firozpur	28.77	Barnala	18.54

Areas with Moderate Level of Physical Infrastructural Development

The figs.1 to 3 depict that in 1971, about 28% of total area of the country was moderately developed in physical infrastructural development which increased to 35% in 1991. It again decreased to 28% in 2011. The study finds out that in 1971, about 30% of total population experienced moderate level of physical infrastructural development which increased to 44% in 1991 and decreased to 30% in 2011. It clearly indicates that between 1991 and 2011 the gap between population size and infrastructural facilities was high than 1971 and 1991.

As per fig.1 in 1971, two distinct clusters along with a certain pockets (especially in southern parts of the study area) with moderate level of physical infrastructural development are visible. First cluster extends over the north western part of the study area covering districts of Jammu & Kashmir, Himachal Pradesh, Punjab, Haryana and western Uttar Pradesh. The second cluster spans over the north eastern region of the study area comprising almost all states of northeast region except Mizoram and Tripura. In 1991, the spatial pattern of moderate level of physical infrastructural development remained almost unchanged with small changes in northeastern region of the country. Fig.3 illustrates that in 2011, majority of the districts of Himachal Pradesh, Haryana, Western Uttar Pradesh, Uttarakhand, Jammu & Kashmir and western parts of Uttar Pradesh in northern part of the country have registered moderate development. Besides, small patches of districts have also been recorded in Tamil Nadu, coastal parts of Andhra Pradesh in southern part and Mizoram and Manipur in north eastern part of the study area. The study finds out that availability of flat terrain, fertile alluvial soil, nearness to national capital and state headquarters and evidences of development processes from British period together facilitated the development of various sectors like transport, communications and agriculture which ultimately resulted into both moderate and high level of physical infrastructural development in the country.

Areas with Low Level of Physical Infrastructural Development

The backwardness in the physical infrastructural development can be gauged from the fact that in 1971, about 56% of total area of the country was poorly developed in physical infrastructural facilities which marginally decreased to 52% in 1991. It again increased to 62% in 2011. Similarly, in 1971, about 57% of total population of the country was recorded in category of low level of physical infrastructural development which decreased to 45% in 1991. Fig.3 depicts that in 2011,

Table 2: Bottom 20 districts by physical infrastructural development in India, 1971-2011

Reference Years					
1971		1991		2011	
Districts	Standardised Index	Districts	Standardised Index	Districts	Standardised Index
Churu	0.35	Guna	0.01	Thane	0.81
Barmer	6.75	Hamirpur	0.12	Yavatmal	0.99
Osmanabad	9.50	Durg	0.25	Buldana	1.76
Nagaur	9.53	Rajnandgaon	0.58	DakshinBastar	2.09
Gulbarga	9.65	Vidisha	0.72	Nadurbar	2.38
Jalor	10.30	Sagar	0.79	Nabarangpur	2.39
Akola	10.89	Surguja	0.99	Shahdol	2.45
Parbhani	11.41	Sidhi	1.09	Solapur	2.48
Tonk	11.48	Ujjain	1.25	Nagpur	2.56
Raichur	11.71	Jhabua	1.33	KurungKumey	2.62
Aurangabad	12.13	Shahdol	1.59	Bastar	2.66

Reference Years					
1971		1991		2011	
Buldana	12.46	Bhopal	1.72	Ramanagara	2.67
Bid	12.47	Indore	2.00	Amravati	2.86
Mahbubnagar	12.50	Yavatmal	2.23	Gulbarga	2.91
Yavatmal	12.63	Khargone	2.23	Umaria	2.93
Nanded	12.68	Satna	2.27	Uttar Bastar	2.95
Jhunjhunu	12.75	Thane	2.30	Akola	2.96
Amravati	13.17	Banda	2.43	Nanded	2.97
Dharwad	13.74	Shajapur	2.46	South Twenty Four Parganas	2.98
Anantapur	13.80	Jodhpur	2.46	Latur	3.10

about 60% of the total population of the country has witnessed poor availability of physical infrastructural facilities. It is a matter of great concern that an overwhelming share of population still grappled with the problem of poor physical infrastructure. A lot needs to be done in this regard. The study reveals that in 1971, whole of Rajasthan, Madhya Pradesh, Maharashtra, Andhra Pradesh, Odisha, Bihar, Gujarat and West Bengal, central & eastern part of Uttar Pradesh have displayed low level of physical infrastructural development. Besides, majority of the districts of the Meghalaya, Nagaland and central part of Arunachal Pradesh also recorded low composite index for physical infrastructure (Fig. 1). The study indicates that development pattern of physical infrastructure has remained almost unchanged with few variations in 1991 and 2011. As evident from figs. 1 to 3 that the large areas in peninsular plateau and eastern part of the study area continued to reel under poor physical infrastructure in India.

The study points out that the undulating and dissected topography, scarcity of rainfall, lack of irrigation facilities because of absence of volume of water in rivers, poor socio-economic conditions, high pressure of population on existing facilities, dense forest cover and dearth of underground water together jeopardised the development of transport, communication and agricultural facilities in these areas.

Areas with Very Low Level of Physical Infrastructural Development

Figs. 1 to 3 exhibits that in 1971, about 11% of geographical area comprising 6% of population had witnessed very low development of physical infrastructure. In 1991, there was stagnant improvement in physical infrastructural development which is evident from declining area i.e. 5% about 4% population of the country. During next two decades, the pace of development of physical infrastructure slowed and extended over about 7% area served 5% population of the study area in category of very low level of physical infrastructural development. It is evident from fig. 1 that in 1971, the areas registering very low composite index were largely located in central parts of the Maharashtra, Rajasthan, northern part of Karnataka, northwestern part of Madhya Pradesh and western part of Andhra Pradesh. In 1991, majority of the districts of Madhya Pradesh also displayed low composite value in physical infrastructure. The study reveals that in 2011, very low level of physical infrastructural development has been recorded in central and eastern parts of Maharashtra and southern parts of Chhattisgarh.

Table 2 represents the districts performing very poorly in physical infrastructural development during 1971 to 2011. It indicates that in 1971, Churu district ranked at the bottom place followed by Barmer, Osmanabad, Nagpur, Gulbarga and Jalor districts. In 1991, Guna district was at the bottom place followed by Hamirpur, Durg, Rajnandgaon, Vidisha and Sagar districts. The study reveals that in 2011, Thane district has recorded lowest composite index value

followed by Buldana, DakshinBastar, Nandurbur and Nabarangpur district respectively.

Conclusions

It is evident from previous analysis that there has been variations in the level of physical infrastructural development in relation to geographic area and population served. In 1971, about 1% area was highly developed in availability of physical infrastructural facilities which remained almost unchanged during next two reference periods i.e. 1991 and 2011. However, the proportion of the population recorded in very high developed category was 3% in 1971 which rose to 7% in 1991 and decreased to 1% in 2011. It may be attributed to higher pace of physical infrastructural development between 1970s and 1980s and slow growth during 1990s and first decade of 21st century. The study reveals the inter-regional disparities in the development of physical infrastructure during the study period. The study shows that the northwestern part comprising of Punjab, Haryana and western part of Uttar Pradesh has witnessed very high and high level of physical infrastructural development. The study finds out that the districts namely Delhi, Chandigarh, Mumbai, Mahe, Manipur West, Lahaul-Spiti, Solan and Panchkula were highly developed in physical infrastructural facilities. The very high level of physical infrastructural development in these districts could be attributed to benefit of being capital headquarters, early start of development process, special government initiatives and good socio-economic background. The Lahaul-Spiti, Saiha and Kolasib districts exhibited very high physical infrastructural development because of low density of population and high factor score for infrastructural facilities like road length, communication facilities namely post offices, telephone exchanges and higher proportion of net irrigated area to net sown area. The study demonstrates that all the districts are different in the context of individual indicators or sectoral development. Chandigarh district stood at top due to well-developed network of transport and communication facilities. Chandigarh remained at the top despite the fact that it was poor performing in agriculture.

The backwardness in the level of physical infrastructural development can be judged from the fact that the share of districts with low composite score has been more than 50% during the study period. The study reveals that a vast tract in the form of a contiguous cluster in peninsular and north central part of the study area is easily distinguishable with low level of physical infrastructural development during all the reference periods. The study brings out that the whole of Rajasthan, Madhya Pradesh, Maharashtra, Andhra Pradesh, Odisha, Bihar, Gujarat and West Bengal, central and eastern part of Uttar Pradesh have displayed low level of physical infrastructural development. The study points out that the undulating and dissected topography, high pressure of population on existing facilities, poor socio-economic conditions, scarcity of rainfall and lack of irrigation facilities because of absence of volume of water in rivers, dense forest cover and dearth of underground water together impeded the development of transport, communication and agricultural facilities which together lowered the level of overall physical infrastructural development. The study reveals that districts namely Churu, Barmer, Osmanabad, Nagpur, Gulbarga and Jalor, Guna, Durg, DakshinBastar, Nandurbur and Nabarangpur have registered very low and low levels of physical infrastructural development.

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