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Conference Paper

Change in Levels of Road Connectivity in Sri Ganganagar District: A Case Study

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Abstract

Road connectivity plays a crucial role in regional development by facilitating mobility, economic activities, and spatial integration. This study examines the changes in the levels of road connectivity in Sri Ganganagar District, Rajasthan, over a period of thirty years (1990–2021). Using graph theory and transport network analysis, the road network was analysed through identified nodes and edges for both time periods. Four structural indices—cyclomatic number, alpha, beta, and gamma—were employed to measure the degree of connectivity at the tehsil level. Additionally, Aggregate Transportation Scores (ATS) were computed to present a consolidated picture of road connectivity. The results reveal significant spatial variations and temporal changes in connectivity across tehsils, with Suratgarh, Ganganagar, and Karanpur showing consistently high connectivity, largely due to the presence of national and state highways. In contrast, tehsils such as Raisinghnagar and Padampur exhibit comparatively low connectivity. The study highlights the improvement in overall road connectivity in the district over time, while also emphasizing the need for focused infrastructural development in less-connected tehsils to ensure balanced regional development.

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KEYWORDS: Road Connectivity; Transport Network; Graph Theory; Alpha, Beta and Gamma Indices; Aggregate Transportation Score; Sri Ganganagar District; Rajasthan

INTRODUCTION

AI is a wide-ranging Road play a major in the development of any region. It is considered an integral part of the transport network of a nation. The term road network is considered a spatial pattern of road transportation facilities in a region. Robinson and Bamford (1978) defined the connectivity of a network as the degree of completeness of the links between nodes. The degree of connection between all vertices is defined

as the connectivity of the network (Taaffe and Gauthier, 1973). Kansky (1963) undertook an extensive empirical analysis of transport network structures and developed several descriptive indices for measuring the connectivity of transport network. Bhaduri (1992) measured the degree of road connectivity in West Bengal by using alpha, beta and gamma indices and observed that highway was designed in such a manner that they were not providing the alternate connections to cities within the state. Saxena (2002) examined the pattern of road transport connectivity in Rajasthan and observed that the batter transport development was along the national highway no. 8, connecting the cities like Jaipur, Ajmer and Udaipur. Rani and Chamar (2016) studied the levels of road connectivity in Haryana and measured aggregate transport scores (ATS) by summing up alpha, beta and gamma indices at the district level.

Study Area

Ganganagar district is located in northern part of Rajasthan between 28°4′ to 36°6′ North latitude and 72°30′ to 74°16′ East longitudes and covers about an of 11154.66 sq. K.M. This is about 3.26 per cent of total state area. The district is bound in north by the state Punjab and in the south It is bordered by the Bikaner district. Its eastern boundary is demarcated by the Hnumangarh district. The northern and western boundaries of district are marked by the eastern boundary of Pakistan. At present for the purpose of administration, the district is divided into five sub-divisions and nine tehsils. Fig-01

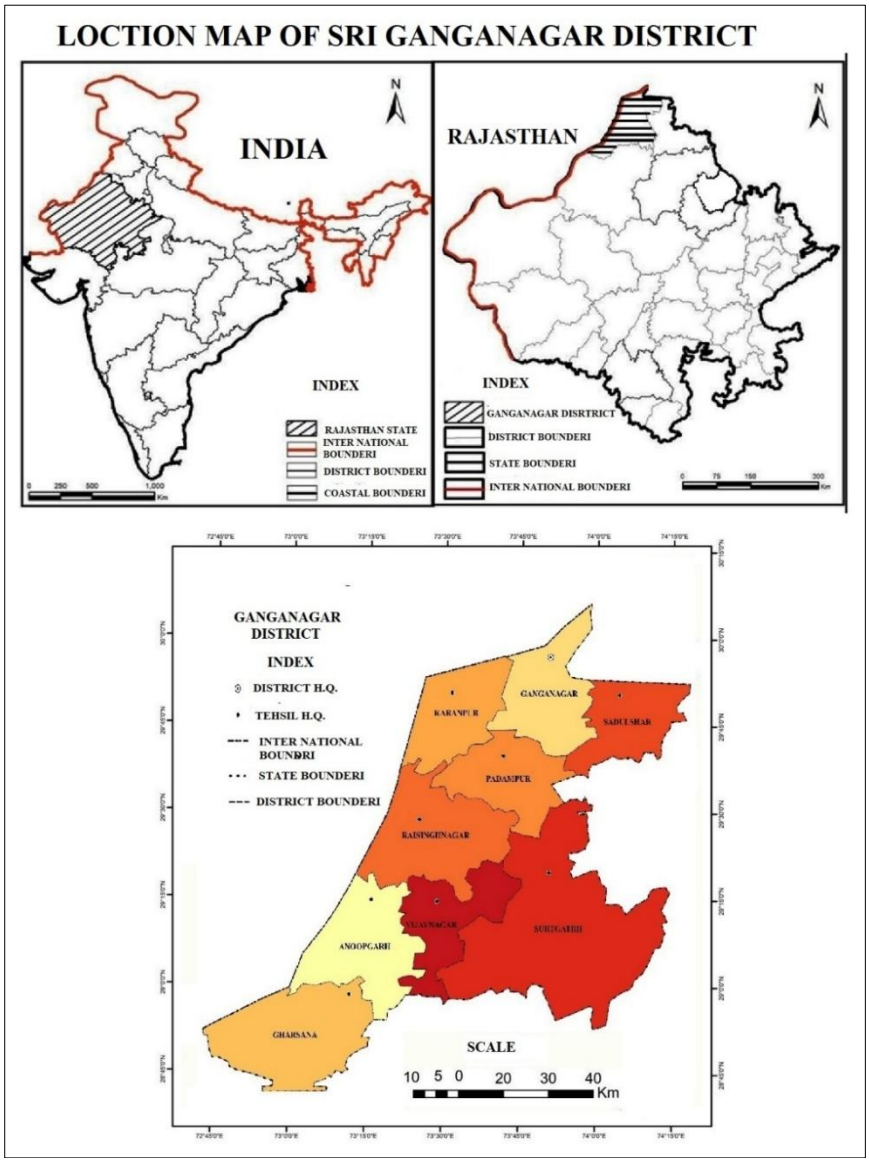


Fig 1: Location map of study area

OBJECTIVES

The main objectives of the study area:

- To analyses the transport network in the district in 1990 and 2021.
- To analysis the changes in various transport network in the district in 1990 and 2021.
- To find the indices of the transport network in the district from 1990 to 2021.

Data Base and Methodology

The present study is based on 1990 and 2021 census data. The nodes have been identified on the basis of following criteria. District headquarters and tehsil headquarters. Tehsil level crossings on national highways, state highways and major tehsil roads. On the basis of above three criteria, 100 nodes in 1991 and 135 nodes in 2021 have been identified. To compare the levels of connectivity. The district boundaries of 2021 have been used for both the years i.e. 1990 and 2021. The topological diagram of road network of Sri Ganganagar has been prepared with the help of 100 nodes and 81 edges in 1990 and 135 nodes and 120 edges in 2021. (Fig. 1&2). The edges crossing the tehsil boundaries have been counted twice by assuming a node for that particular tehsil. For example the edge connecting Ganganagar and Karnpur has been counted for both the tehsil, so in order to explain the connection a node has been assumed in both the tehsil which mean the inter-tehsil edge is considered as two edges. Thus the total number of nodes and edges counts up to 100 and 81 in 1990 and 135 and 120 in 2021. Respectively (Table-1) Four indices i.e. cyclomatic number, alpha, beta and gamma have been used to calculate the tehsilwise road connectivity. Futher aggregate transport scores have also been computed by adding the value of three indices i.e. alpha, beta and gamma. Qgis (version 2.18) software has been used to prepare the maps.

Results and Discussion

Cyclomatic number (μ)

The cyclomatic number of transport network is defined as the number of circuits in a network. A highly connected topological grapha will have higher values of μ and vis-à-vis algebraically, the cyclomatic number can be computed by the following equation.

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

Here –
μ = Cyclomatic number
e = Number of edges
v = Vertices (Nodes)
p = Non connected sub-graph.

In 1990 three tehsil (Sadulsahar, Raisinghnagar and Anoopgarh) are having a score of zero and three tehsil value one from Ganganagar Karnpur and Gharsana. The highest value i.e. three of cyclomatic number in Surtgarh tehsil. The negative cyclomatic value of Padampur -1 and Vijaynagar is -3. In 2021 the maximum value 6 of cyclomatic number is recorded in Surtgarh tehsil and minimum (0.0) in Padampur, Sadulsahar, and Rawla tehsil.Ganganagar and Gharsana tehsil cyclomatic value 2, Karnpur and Anoopgarh 1, Vijaynagar is 3 and Raisinghnagar is -2.The highest value cyclomatic number in 1990 and 2021 Surtgarh tehsil in national highway 15 and state highway 6 in the district. The total values of this index have increased in the tehsil and the regional pattern has been changed in thirty years (1990 – 2021) in Ganganagar district in Ganganagar, Raisinghnagar, Surtgarh and Gharsana tehsil.

Alpha index - (α)

This index is the ratio between the number of circuits in a network system and the total possible circuits in network. The index varies between zero to one, higher values indicate higher levels of connectivity of the network and vice-versa. It is measured as-

$$\alpha = \frac{e - v + g}{2v - 5}$$

Here –
α = Alpha index
e = Number of edges
v = Vertices (Nodes)
g = Non connected sub-graph

In 1990 alpha index ranges from zero (0.0) in Raisinghnagar, Sadulsahar and Anoopgarh tesil, and Vijaynagar 0.09, Padampur 0,05, Ganganagar 0.07, Gharsana 0.09, and Karnpur 0.14 value. In 2021 it is observed that more the Surtgarh tehsil 0.18 and Padampur, Sadulsahar, Gharsana and Rawla tehsil value in zero (0.0), and Anoopgarh 0.04, Vijaynagar 0.07, Risinghnagar 0.06, Surtgarh 0.14 vilue. Five tehsil in Ganganagar, Raisingnagar, Surtgarh, Vijaynagar, and Anoopgarh tehsil in increase vilue in 1990 to 2021.

Beta - (β)

This index gives the average number of edges available per vertex. It is mathematically expressed as.

$$\beta = e / v$$

Here –
β = Beta
e = Number of edges
v = Vertices (Nodes)
Whear, values of e and v are as per equation (i).

Beta index is 01 in three tehsil of the district in 1990. These tehsil are Ganganagar, Karnpur, and Gharsana respectively. Thew highest beta index in the years 1990 in the district is 1.08 in Surtgarh tehsil. While the minimum index is 0.53 in Vuijaynagar tehsil., The index of other tehsil of the district is Padampur and Anoopgarh is 0.75, Sadulsahar 0.90, and Raisinghnagar 0.65. The highest beta index in the year 2021 in the district is 1.21 in Surtgarh tehsil, the lowest index is 0.68 in Raisinghnagar tehsil, while beta index is lass then 01 in other tehsil. Chage in beta index in all tehsil. Except Karnpur tehsil in the last 30 years in the district. It was found thet the chang is in Ganganagar and Surtgarh tehsils,the main reason for withen is the passing of NH-15 and SH- 07 in the tehsils, due to within the haist value was found in traffic routs.

Gamma Index- (γ)

It is a relative index of network connectivity expressed as a ratio of actual number of edges to the total number of edges possible in the network between 0 and 1. It calculated as.

$$\gamma = \frac{e}{3(v-2)}$$

Here –
γ = Gamma index
e = Number of edges
v = Vertices (Nodes)

The minimum gamma index in the district in 1990 is 0.30 in Anoopgarh tehsil, while the maximum gamma index is 0.50 in Karnpur tehsil, other tehsil of the district gamma index lase than 0.50, while the maximum gamma index in the years 2021 in the district is 0.50 in Karnpur tehsil, while the minimum gamma index is 0.25 in Raisinghnagar tehsil, gamma index is 0.43 in Ganganagar and Gharsana tehsils for the year 2021.

Aggregated Transportation Scores

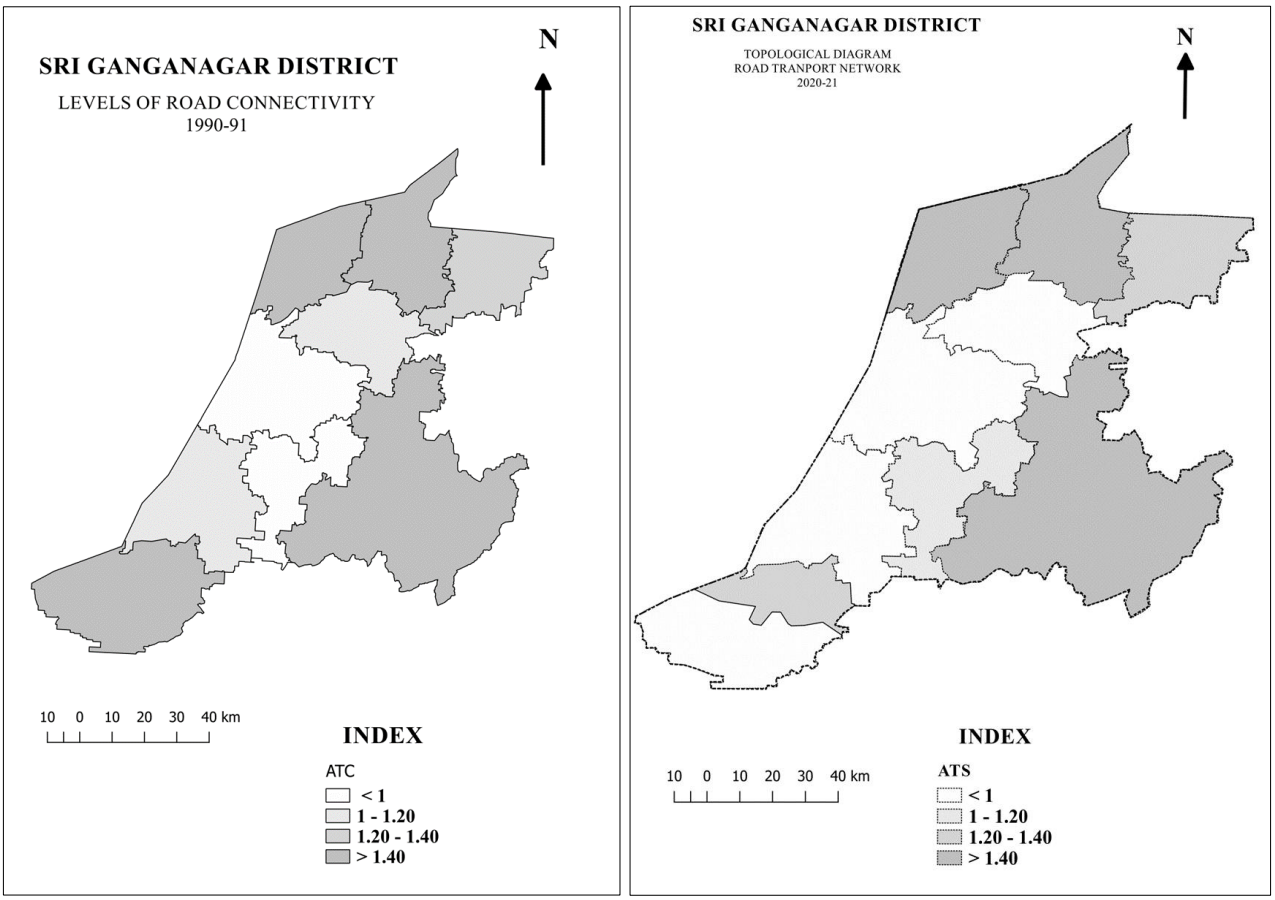
A consolidated picture of the levels of rods connectivity has been presented by applying the technique of Aggregated Transportation Scores. As cyclomatic number is an absolute value and other three indices have relative values, therefore only the values of alpha, beta and gamma indices have been considered to calculate aggregate transportation scores in the present study.

Table 1: Gangangar District Tehsilwise Structural Indices and Aggregate Transport Scores 1990-91 to 2020-21

S.N.	Tehsils	Total Nodes		Total Edges		Cyclomatic Number		Alpha Index (a)		Beta Index(b)		Gamma Index(c)		ATC (a+b+c)	
		1990	2021	1990	2021	1990	2021	1990	2021	1990	2021	1990	2021	1990	2021
1	Ganganagar	9.00	12.00	9.00	13.00	1.00	2.00	0.07	0.11	1.00	1.08	0.42	0.43	1.49	1.62
2	Karnpur	6.00	6.00	6.00	6.00	1.00	1.00	0.14	0.14	1.00	1.00	0.5	0.5	1.64	1.64
3	Padampur	12.00	15.00	9.00	12.00	-1.00	0.00	0.05	0.00	0.75	0.8	0.3	0.31	1.10	1.11
4	Sadulsahar	11.00	11.00	10.00	10.00	0.00	0.00	0.00	0.00	0.9	0.91	0.37	0.37	1.27	1.28
5	Raisinghnagar	11.00	19.00	7.00	13.00	0.00	-2.00	0.00	0.06	0.63	0.68	0.26	0.25	0.89	0.99
1	Surtgarh	12.00	19.00	13.00	23.00	2.00	6.00	0.11	0.18	1.08	1.21	0.43	0.45	1.62	1.84
7	Vjaynagar	19.00	23.00	10.00	19.00	-3.00	3.00	0.02	0.07	0.53	0.83	0.19	0.31	0.74	1.21
8	Anoopgarh	12.00	14.00	9.00	11.00	0.00	1.00	0.00	0.04	0.75	0.78	0.3	0.31	1.05	1.13
9	Gharsana	8.00	6.00	8.00	5.00	1.00	2.00	0.09	0.00	1.00	0.83	0.44	0.43	1.53	1.26
10	Rawla	0.00	10.00	0.00	8.00	-1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.33	0.00	1.13

Table 2: Ganganagar District Chang in Levels of Road Connectivity 1990-91 to 2020-21

1990-91				
S.N.	**Levels of Road Connectivity**	**Range of Values**	**No of Tehsils**	**Name of Tehsils**
1.	High	>1.40	04	Karnpur, Surtgarh, Ganganagar, Gharsana
2.	Moderate	1.20 – 1.40	01	Sadulsahar
3.	Low	1 – 1.20	02	Padampur, Anoopgarh
4.	Very low	< 1	02	Raisinghnagar, Vijaynagar
2020-21				
S.N.	**Levels of Road Connectivity**	**Range of Values**	**No of Tehsils**	**Name of Tehsils**
1.	High	>1.40	03	Karnpur, Surtgarh, Ganganagar,
2.	Moderate	1.20 – 1.40	03	Sadulsahar Vijaynagar, Gharsana
3.	Low	1 – 1.20	03	Padampur, Anoopgarh, Rawla
4.	Very low	< 1	01	Raisinghnagar,



In 1990 highest aggregate transportation scores value is > 1.40 in Karnpur, Surtgarh ana Gharsana tehsils, while average value is 1.20 to 1.40 in Sadulsahar tehsil in medium level, the lwest level in Padampur and Anoopgarh tehsils, the very lowst has been found in Raisinghnagar and Vijaynagar tehsils of < 01., while ther has been chang in the transport network in the district in the last 30 yers. In 201 highest value > 1.40 in found Ganganagar, Karnpur and Surtgarh tehsils, the moderate value 1.20 to 1.40 in Sadulsahar, Vijaynagar and Gharsana tehsils, lost value in Padampur Aoopgarand and Rawla tehsils, the very lowest value in in Raisinghnagar tehsil.

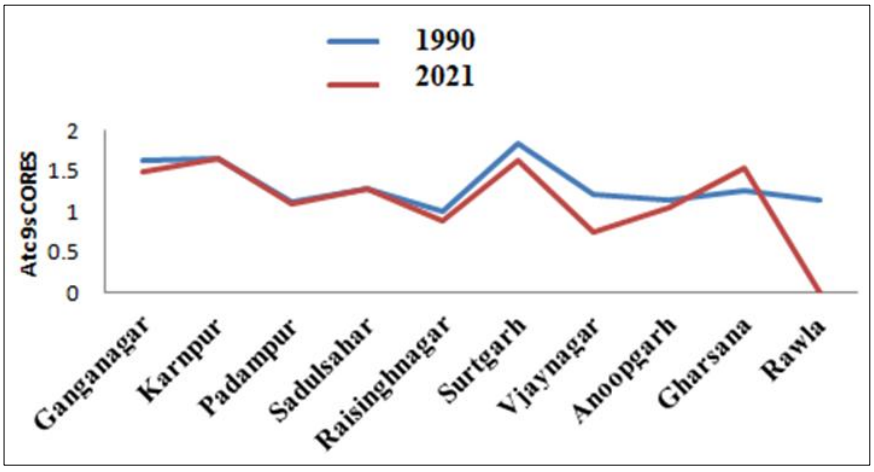


Fig 3: Aggregated transportation scores

CONCLUSION

The research paper concludes that Ganganagar District in north tehsil ware Ganganagar, Karanpur and Suratgarh in both session in high road connectivity, and other tehsils in low connectivity. Finally suggested that more emphasis should be laid on the urbanization and development processes by providing infrastructural facilities such as medical, education, trade, commerce and banking etc. in extreme other tehsils for the creation of new nodes and construction of roads to stimulate the connectivity of road in the study area.

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