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E: ISSN NO.: 2455-0817 Remarking An Analisation

Measurement of Road Network Accessibility at District Level – A Case for Alwar District, Rajasthan, India

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Abstract

This paper demonstrated rapid methodology (minimal use of secondary data) to measure the road network accessibility at the district level. The graph theory, RAI the graph theory,AI,Buffering and normalization techniques. (z-square) has been used for the measuring the road network structure and Accessibility, while using the variety of tools including GIS and AutoCAD software's has been used for the process the spatial data. Also ArcGIS and Imagine process software has been used for map making through digitization, geo-referencing, over-laying the different layers, and buffering analysis. The statistical tools as MS- Excel, and Power-BI have been used for analysis. Moreover, the study would help to find the correlation of road network accessibility with socio-economic development of the district. The major finding from a study suggests that Alwar district is homogenous in nature ,and the accessibility of road network is moderate.

Keywords: Accessibility, Development, District, Socio-Economic.

Introduction

Transport means to carry or to convey. The concept of transport or transportation seems mundane enough. It affects all most all the aspects of daily life. Development of road network plays a significant role in the socio-economic improvement of a region. Transportation is an essential function in the development equation (Ramachandran).So one can easily say that the transport sector with higher efficiency is an essential component of the economy impacting on the development and the welfare of populations. Moreover; transport network development is considered to be one of the keys to rapid modernization and development, especially for better traffic efficiency. Good network efficiency saves time and cost saving as well as gains in accessibility and reliability. This study has used various methods to determines the road network structure and accessibility at the district level.

The study first presents a brief introduction to the case study Alwar district, followed by the data collection, analysis, and findings. We show the use of graph theory, RAI, buffering and normalization techniques (z-square) have been used for the measuring the road network structure and Accessibility, while using the variety of tools including GIS and Auto CAD software's has been used for the process the spatial data. Also ArcGIS and Imagine process software has been used for map making through digitization, geo-referencing, over-laying the different layers, and buffering analysis. The statistical tools as MS- Excel, and Power-BI have been used for analysis. Moreover, it would help to find the correlation of road network accessibility with socio-economic development of the district. Then study present a discussion on the idea of measuring road network accessibility and its implication the socio-economic development of the district, followed by conclusion and recommendation.

Based on the experience gained from the research it has found that, before preparing the road infrastructure investment proposal, the policymaker may refer to the quantification method discussed in this research. The vulnerable region may be identified by using the quantification method as discussed in this research. Also, the PMGSY and IDA indicator must refer to any road network accessibility measured. It would help to prioritize the investment in road infrastructure. Accessibility to the basic socio-economic amenities has to measure as the method discussed in this research.

Review of Literature

Transport has an impact on the level of development of a region. Here we chronologically present a brief overview in the case studies. (K.K), (O. Filani), (P.S), (Simon), (Linneker and Spence), (Sreelekha, K and M), (A and Qiang). These studies are selected as each of them focuses on different aspects of quantification of road network measures, which we discuss in the context of our study. These studies are very detailed, and therefore not all aspects are discussed here.

(K.K) Has tried to demarcate the importance of road transport in Rajasthan. His main aim is to explain the reason due to which railways could not well developed in this region according to its area. He gave importance to the motor vehicles and stated that a well-developed road network had developed mainly in the capital city of Rajasthan.

(Sreelekha, K and M) tried to measure the transport network efficiency by the alpha, beta and gamma indices for connectivity using formulas developed by (Patarasuk) gave reasons responsible for low connectivity and concluded it with the remark that transport network development is considered to be one of the keys to rapid modernization and development, especially for better traffic efficiency.

(Darren M, David C, and Lisa) and (Bhat, Handy and Kockelman) Used the network robustness index to identify critical links and evaluate the performance of transportation networks. Also, this paper presents a new, comprehensive, system-wide approach to identify critical links and evaluating network performance. This approach considers network flows, link capacity and link typology instead of traditional volume/capacity (V/C) ratio to identified highly congested or critical links. Moreover, they demonstrate that the robustness index (NRI) provides a better indication of the value associated with individual links of a highway network than the traditional V/C ratio.

(A and Qiang) Proposed a network efficiency measure for congested networks that captures demands, costs, flows, and behavior. The network efficiency measure can identify which network components that are, nodes and links have the most significant impact in terms of their removal hence, and they are an essential component of the network efficiency.

One such study relates the level of development of rural areas of Nigeria with particular reference to road transport development. (O. Filani) Identified the crucial link between the developments of the transport network and rural development and indicated that the development of transport efficiency has a positive impact on rural development. Rural transport should constitute an integral part of national transport planning and development. Sound rural transport policies should be formulated to make the rural areas more accessible, more integrated into national economies and, in consequence, more productive and more liveable.

In another such study, (Simon) tried to explore the linkages between transport and development. One of the chapters of this book is about ways of looking at development and the role played by transport. Three principal theories are set out and discussed: modernization, political economy, and postmodernism. Simon tries to explore the linkages between the development of economy and transport network development through theories and found it positively linked, higher the level of efficiency higher the level of development.

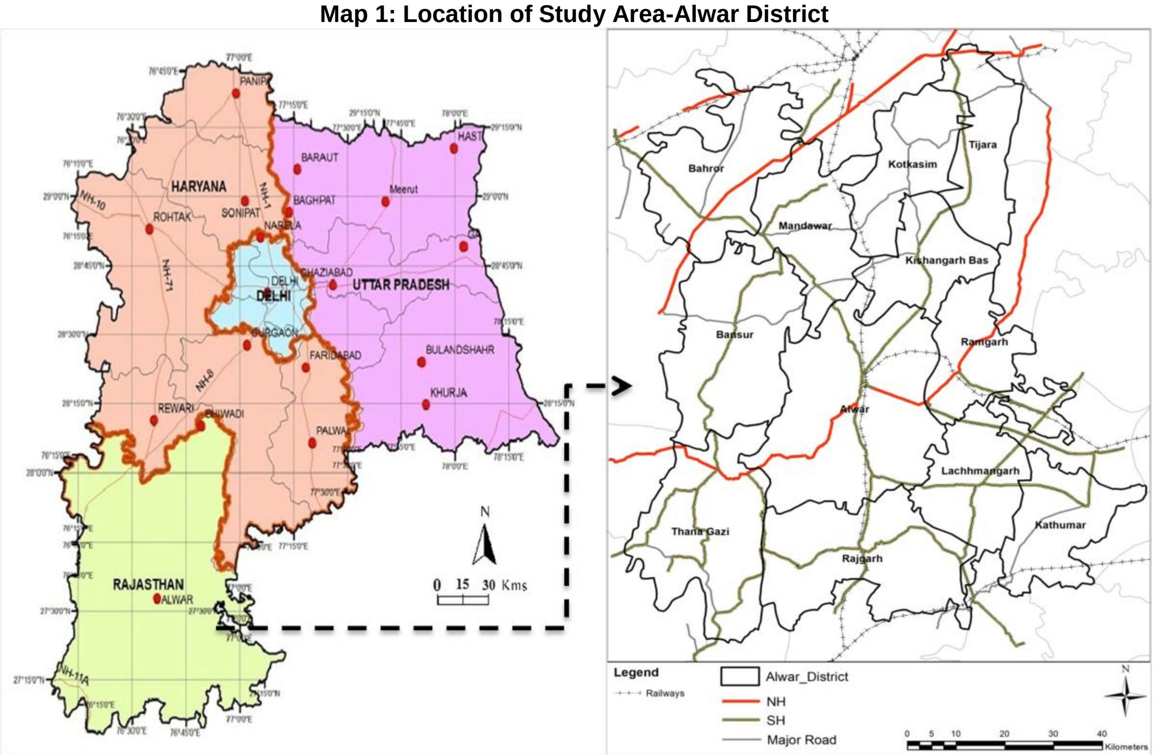
Again (Linneker and Spence) attempted to correlate the road transport infrastructure and regional economic development. The road network supports a whole variety of dependent economic activity and serves to integrate the economic system and facilitate its transactions in geographical space. Moreover, network efficiency has directly correlated with the level of development of an economy

(B.C) In his book "Geography of Transport Development in India" (2003) has considered that the means of transport demand is continuously increasing in human life as it facilitates the movement of people and commodity from one place to another on earth surface. The progress in industrial and other productive sector is entirely related to readily available transport means at a local level. Moreover, therefore, it is necessary to have better linkages between nodes, junctions, nodal points, and industrial sites. He has rightly considered this transport aspect as a spatial expression at the national and regional level besides the metropolitan transport system as a factor of movement.

A Brief Introduction to Alwar District

National capital region (NCR) is the country's first experimental region, which consists of an inter-state region with having the core of NCR. As a constituent of National Capital Region, Rajasthan Sub- Region lies in the south-western part of National Capital Region. The Rajasthan Sub- Region (Alwar) covers an area of 8290 sq. Km. The Alwar city lies 150 km west towards the Jaipur and 170 km North towards the Delhi. NH-8 (Delhi–Jaipur Road) passes through RSR and connects Gurgaon, Maneswar, Bawal and Rewari within the NCR (Map 1). The NH-11A is passing through the Alwar district, and NH 71B connects Rewari to Palwal in the north. There are 11 State Highways i.e. SH-13, 14, 22, 25, 25A, 29A, 35, 44, 45, 52 and 55. The Railway lines connected to the Delhi and Ahmadabad with broad gauge rail line, which passes through the Jaipur, the state capital.

Map 1: Location of Study Area-Alwar District



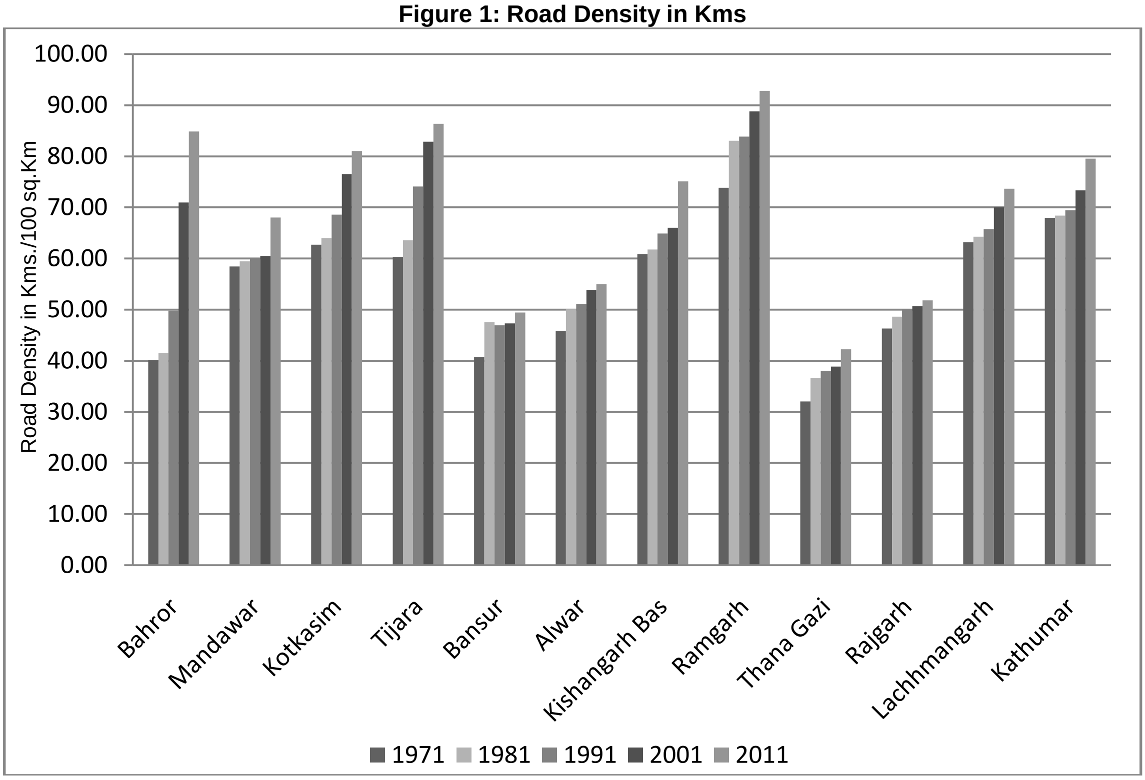
Source: (Board, 2009-2010)

Measurement of Road Network Accessibility

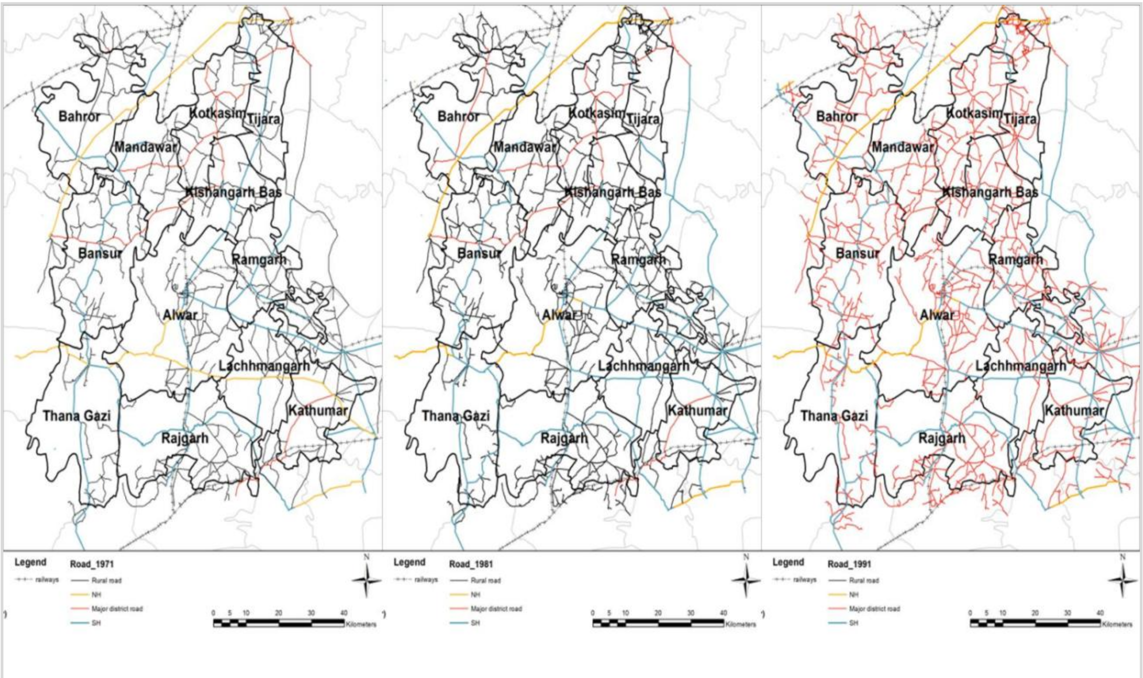
Growth of Road Network

Alwar district, to the total area of these twelve tehsils, works out to be 8290 km2, which is 2.5 % of the state and the total length of road is 5431 km. Road network distribution pattern in Alwar presented in Map 2 and Map 3 over the period of 1971-2011.Road density has derived for each sub-district, by calculating total road kilometer of sub-district divided by the total area of sub-district at presented in Figure 1.

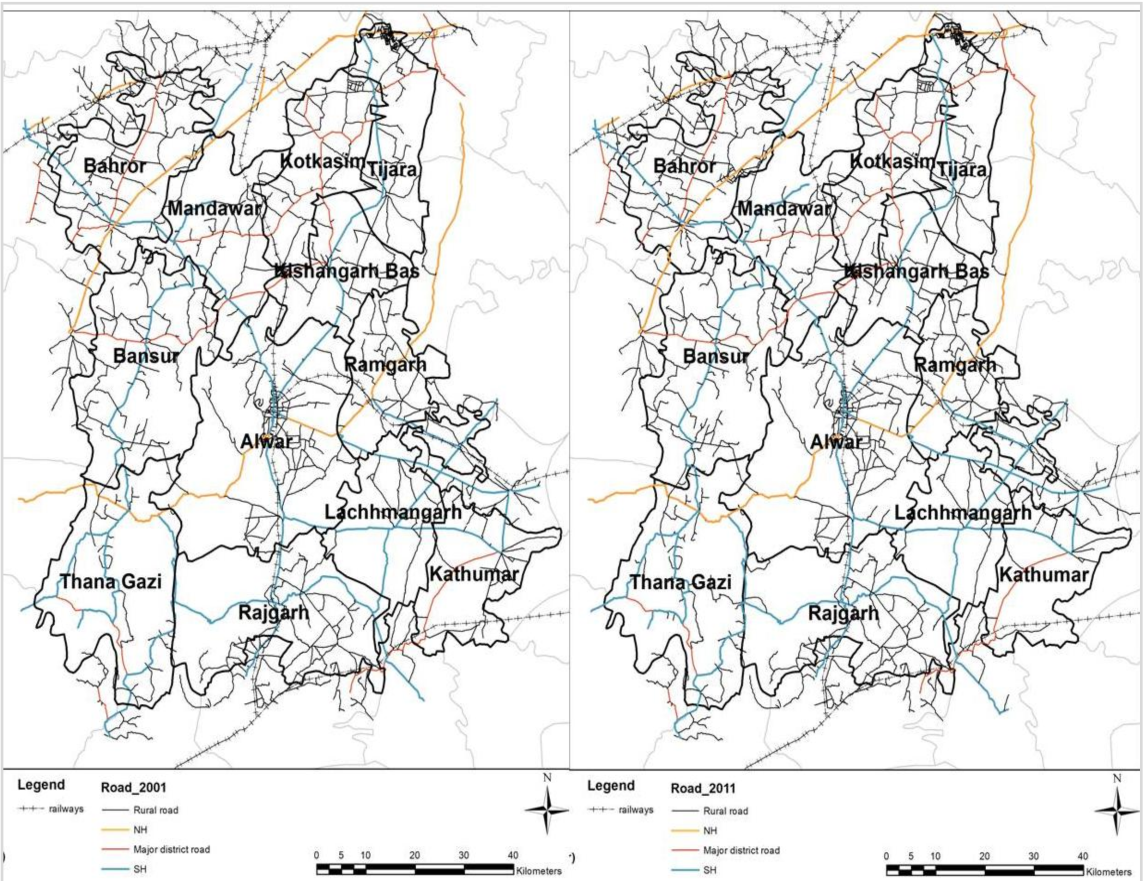
Figure 1: Road Density in Kms



Map 2 : Alwar District - Road Network 1971 & 1981 & 1991



Map 3: Alwar District - Road Network 2001 & 2011

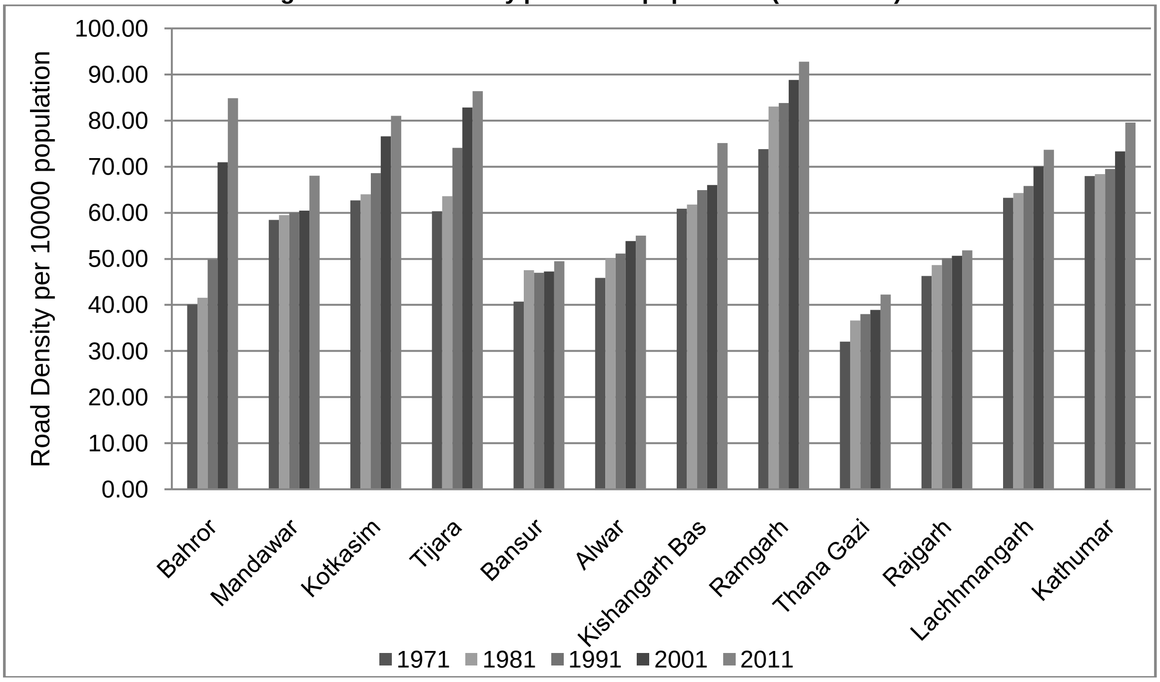


Road Accessibility Measures in Alwar District

Road Density at Population level (10000) = ∑Total road kms*10000 / ∑total population of sub-district.

Figure 2 shows the road network density per 10000 population.

Figure 2: Road density per 10000 population (1971-2011)



The RAI method (developed by IDA) used for analysis of all-weather road improvement impact on the accessibility in a rural area at a regional level. The mathematical expression of RAI;

RAI (IDA) = (Population living within 2.0 km of band area of both sides of all-weather roads / Total population of the block)*100 Table 1 presents the output from the RAI method, and it has analyzed that average 45.54% of the total village has access to the pucca road within the distance of 2.0 km buffer.

Table 1: Number of Village Access to Pucca Road (RAI)

Sr.No	Sub-District	Area(sq.km)	Buffered Area (sq.km)	No of Villages access to road within 2 km distance	Accessible village (%)
1	Bahror	727.65	692.50	76	40.42
2	Mandawar	588.77	453.50	65	44.52
3	Kotkasim	506.33	455.30	70	59.83
4	Tijara	480.32	345.23	67	35.08
5	Bansur	900.16	510.19	96	65.31
6	Alwar	1318.03	844.50	108	54.82
7	Kishangarh Bas	438.07	407.98	57	51.35
8	Ramgarh	428.00	325.56	63	65.20
9	Thana Gazi	888.43	460.61	66	37.71
10	Rajgarh	893.85	507.12	98	38.13
11	Lachhmangarh	635.87	365.67	88	60.10
12	Kathumar	484.45	194.33	69	62.40

Road Connectivity Measures in Alwar District

Accessibility of the road network can measure in distance or time (cost) (Haggett, 1965). This kind of study would appropriate to study the individual location. Since the selected region in the research is the micro level, so the only aggregate road network pattern has obtained. Considering these measures, analysis of the road network has been obtained in the study, so that the accessibility of the region can assessed.

There are some common aspects has attached with network analysis, which has to clarify due to the limitation of the study at the district level to define the elements of the network.

Vertices

It has defined as the point, in the topography, where it lines coverage. In the spatial framework, junction or node commonly the foci (vertices) of the road linkages of the transport network. The vertices in the present study are those nodes or junction which has joined or line with road network linkages.

Edges

It has defined as the major linkages between two vertices (at least). The topographical graph can have derived into two parts 1.Planar and 2.No-Planner graph. In the present study, the edge represented by all-weather roads. Table 2 presents the number of Edges and Nodes throughout 1971-2011.

Table 2 : Number of Edges and Nodes in Tehsil

Year	1971		1981		1991		2001		2011	
Sub-District	Edges	Nodes	Edges	Nodes	Edges	Nodes	Edges	Nodes	Edges	Nodes
Bahror	40	31	44	34	66	55	110	103	157	104
Mandawar	48	28	52	30	56	31	59	40	75	46
Kotkasim	39	36	43	38	50	42	55	56	62	61
Tijara	67	34	131	52	143	63	302	70	400	72
Bansur	72	63	84	73	93	75	88	78	96	85
Alwar	139	86	151	103	170	113	220	187	231	194
Kishangarh Bas	30	25	35	28	38	29	82	81	106	132
Ramgarh	28	25	39	37	41	38	37	39	43	45
Thana Gazi	54	30	74	36	88	47	102	56	121	66
Rajgarh	51	38	60	46	64	50	68	64	71	65
Lachhmangarh	33	16	37	20	43	26	39	33	46	36
Kathumar	30	16	33	18	35	20	34	26	61	34

The application of graph theory on road network has taken in this research for understanding the structure and accessibility of the network. There is a number of indicators have been tested in for measuring the network connectivity and accessibility. All indicators have aggregated into the single plateform, to identified homogeneity and heterogeneity of the transport region in a district.

In this research Alwar district has been divided into three different regions with the help of the seven indicators. The seven indicators are as follow;

1. Alpha Index [1]
2. Beta Index [2]
3. Gamma Index [3]
4. Eita (Average road length per km)[4]
5. RAI
6. Pi index[5]
7. Cyclomatic number [6]

After selecting the seven indicators, they have been segregated based on the weighted. This weighted has been decided based on the importance of each indicators impact of the district road network.

Table 4 and Table 5 has shown the weightage, indicator of the road network and components indicator index score respectively.

Table 3: Individual Indicator Weightage

S. No.	Indicator	Weight
1	Alpha	2
2	Beta	5
3	Gamma	3
4	Eita	6
5	RAI	7
6	Pi	4
7	Cyclomatic Number	1

Table 4: Indicators of Road Network Accessible Region

Sub-District	Alpha	Beta	Gamma	Eita	RAI	Pi	Cyclomatic Number
Bahror	0.15	1.27	0.04	2.71	57.45	0.02	21.00
Mandawar	0.38	1.67	0.09	3.70	61.29	0.03	25.50
Kotkasim	0.06	1.08	0.04	4.59	70.58	0.04	11.00
Tijara	0.35	3.33	0.12	0.72	73.45	0.01	8.00
Bansur	0.09	1.16	0.03	3.22	46.39	0.02	4.00
Alwar	0.20	1.39	0.02	2.04	51.20	0.01	30.50
Kishangarh Bas	0.08	1.12	0.05	2.15	65.74	0.02	40.50
Ramgarh	0.03	1.03	0.05	4.81	84.47	0.05	46.00
Thana Gazi	0.48	1.88	0.08	2.15	37.57	0.02	38.00
Rajgarh	0.12	1.22	0.04	4.50	49.51	0.03	30.50
Lachhmangarh	0.37	1.61	0.11	5.03	67.40	0.03	50.00
Kathumar	0.43	1.71	0.14	4.51	71.75	0.04	29.50

Table 5 : Components of Road Network Accessible Region Index Score

Sub-District	Alpha	Beta	Gamma	Eita	RAI	Pi	Cyclomatic Number
Bahror	0.27	0.11	0.16	0.46	0.42	0.25	0.37
Mandawar	0.78	0.28	0.59	0.69	0.51	0.49	0.47
Kotkasim	0.05	0.02	0.21	0.90	0.70	0.87	0.15
Tijara	0.72	1.00	0.78	0.00	0.77	0.00	0.09
Bansur	0.13	0.06	0.09	0.58	0.19	0.41	0.00
Alwar	0.39	0.16	0.00	0.31	0.29	0.13	0.58
Kishangarh Bas	0.10	0.04	0.25	0.33	0.60	0.36	0.79
Ramgarh	0.00	0.00	0.27	0.95	1.00	1.00	0.91
Thana Gazi	1.00	0.37	0.47	0.33	0.00	0.21	0.74
Rajgarh	0.21	0.08	0.19	0.88	0.25	0.57	0.58
Lachhmangarh	0.75	0.25	0.73	1.00	0.64	0.50	1.00
Kathumar	0.90	0.30	1.00	0.88	0.73	0.84	0.55

After allocating weightage, each indicator has been converted into the unit less value for mapping the transport region for a district. The different indicators values have converted by using the standardized units of normalization technique, which based on the following formula;

Xij = Xij –Min {Xij} / Max {Xij} – Min {Xij}

Based on the normalization technique, the value of each indicator has come under the 0 to 1. 0 Map 4 Road network accessible region shows the transport region of the district. The high level of transport regions occurs in the southeast part, north, and middle of the district area. The following tehsil has high transport region including, Ramgarh, Lachhmangarh, and Kathumar. These tehsils mainly lie on the national highway and state highways.

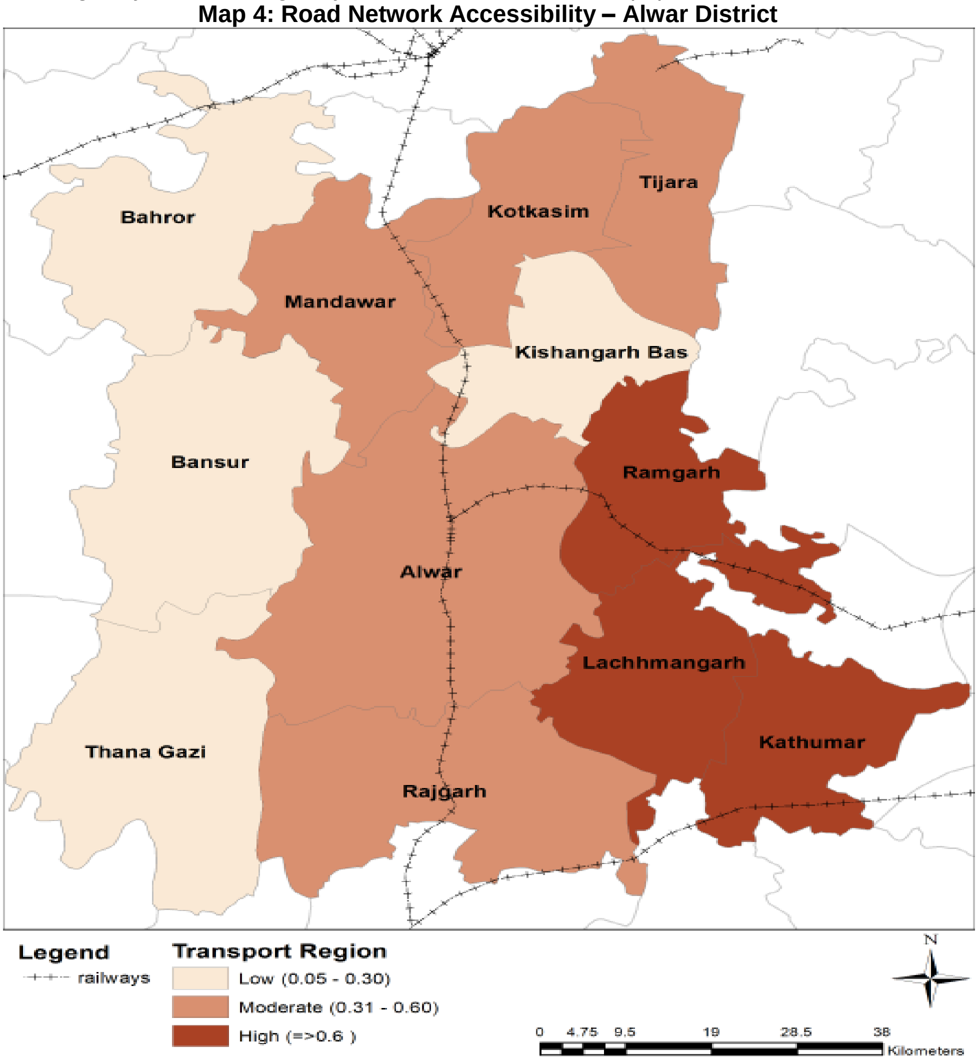
refer to the less transport region and values near to 1 refer to the high transport region. Also, the district has divided into 3 transport region based on the normalization technique.

1. Low transport region
2. Moderated transport region
3. High transport region

Based on the normalization values have been transferring into the map by using GIS software.

While the moderated level of the transport regions has mainly concentrated in the middle part of the district, it is because this tehsil is mainly devoid with surface road due to the natural barrier, excluding Tijara and Mandawar whereas low (weak) transport region occurs at West direction of the district, which has less population concentration and development.

Map 4: Road Network Accessibility – Alwar District



Conclusion & Recommendation

Improving physical access and mobility is a crucial factor for socio-economic development. The current study analyzes the road network characteristics and accessibility of the Alwar district. Based on the graph theory, buffer methods, RAI indicators and normalization techniques (Z-square) have been used to identify the utmost and vulnerable accessible locations in the region. From the analysis of road network following observation has drawn;

1. The road network physical structure and accessibility have observed high on the south-east part of the Alwar district.(Ramgarh, Lachhmangarh, and Kathumar)
2. The moderated level of the road network physical structure and accessibility has mainly concentrated in the middle part of the district. It is

because this tehsil is mainly devoid with surface road due to the natural barrier.

3. The low (poor) of road network physical structure and accessibility occurs at West direction of the district, which has less population concentration and development.

Overall in terms of the road network performance on physical structure and accessibility is less. Out of 12 tehsil 3 has the high (0.6) accessibility index, other all tehsil are legging. Only 25% of the total road is accessible to habitation, which present Alwar as vulnerable district in the NCR region.

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Footnotes

1. *Alpha index – a = e-v+p /2v-5 (p = No.of graph in circuit)*
2. *Beta index – β =e/v*
3. *Gamma Index – γ = e/3(v-2) (planar graphs) and γ = e/v(v-1)/2 (non-planar graph)*
4. *Eita index - η = L (G) / e L(G) is average road length*
5. *Pi Index - Π = L (G) / D (d) D(d) is diameter of tehsil*
6. *Cyclomatic Index - C= e-v+p*