TRANSPORT NETWORK ANALYSIS: A CASE STUDY OF PERAMBALUR DISTRICT (TAMIL NADU) USING GIS

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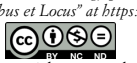
Abstract: Road transport is the main mode of transportation in developing countries, as it allocates flexibility to the commonly scattered spatial configuration. Improving the road transport system increases accessibility and mobility, thus reducing travel costs and travel time. A good road transport system can bring many benefits to a country because transport is a mechanism for economic and social progress. Hence, the Road Transport System across the Perambalur District was selected as the study area for the preparation of the basic map. In this study area, we use the Alpha, Beta, Gamma, Cyclometric, Pie Index, Eta Index, Theta Index, Grid Tree Proportion Index, Network Density, Connectivity, Accessibility and Detour Index parameters to understand the topology pattern and road transport system in the study area. In this study, ArcGIS 9.3 software is used to digitize traffic network data, build a network dataset, and analyse the network using graphical theoretical steps to model network configuration. From Perambalur towns to other vertices, the distance is small and so it can be connected to all the vertices easily which indicates that the transport network pattern is good in Perambalur town.

Keywords: India, transport, connectivity, Perambalur District, GIS.

INTRODUCTION

The transport system enhances the movement of goods and services and consequently forms the source of development for the economic and social sectors because they link places together. Hence the transport system becomes one of the basic needs for any region in the world. When we look at transport planning and decision-making strategies of cities of developing countries, most of the time, planning decisions are made based on pure speculation and it is hard to explain how decisions may affect the road network plan: "transportation is

ISSN 2283-7949
GLOCALISM: JOURNAL OF CULTURE, POLITICS AND INNOVATION
2020, 2, DOI: 10.12893/gjcpi.2020.2.9
Published online by "Globus et Locus" at https://glocalismjournal.org



a measure of the relations between areas and is therefore an essential part of geography" (Ullman 1954). The relations and connections between areas are frequently reflected in the character of transportation facilities as is the flow of traffic involving the basic geographical concepts such as "Spatial interaction and areal association". The study of transportation is an understanding of spatial organization. This concerns all spatial interactions, movements and connections and has been summed up by French geographers in the word "circulation". Transportation fascinates geographers for two reasons: firstly, for its transport infrastructures, terminals, equipment and networks which occupy a vital role in a region, constituting the basis of a complex spatial system and secondly for its spatial relationships and networks which are the main support. Berry (1959) introduced the geographic matrix to relate transport with space economy. Wheeler (1973) proposed a policy-oriented transport study in which social and economic themes become much more integrated. Hensher et. al. (2004) provides a systematic and methodologically detailed coverage of many analytical aspects of transport geography. As Hanson (2006) remarked, enhancing awareness of the centrality of transportation to many if not most geographic problems and making transportation studies once again vibrant is central to the study of human geography. Rodrigue et al. (2006) provide an excellent perspective on the concept, methods and applications in modern transport geography. Jenelius (2008) studied the network structure and travel patterns disparities in the United Kingdom. Touya (2007) applied GIS (geographic information system) for road network selection process based on data enrichment and structure detection in France. Bogale (2012) evaluated transport network structure in Addis Ababa in Ethiopia using graph theory. Kurdistan Jaiswal et al (2012) developed a weighted regression model for the use of public transport in Bhopal. Subbarao and Krishna Rao (2013) focused on the activity-travel diary method of administration and multinomial logit model developed for understanding the mode choice behaviour of individuals in the Mumbai metropolitan region.

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STUDY AREA

Perambalur is a revenue district in the State of Tamil Nadu in India. The district headquarters is located in Perambalur. The district occupies an area of 1,752 km² and has a population of 565,223 making it the least populous in the State. Perambalur district is a centrally located inland district of Tamil Nadu. The district lies between 10^0 54" and 11^0 30" degree northern latitude and 78^0 40" and 79^0 30" degree eastern longitude. The district is bound on the north by Cuddalore and Salem districts, south and west by Tiruchirappalli district and east by Ariyalur district. Perambalur district experiences hot weather throughout the year. The mean maximum actual temperature varies from month to month; the highest was recorded during May 2018 with 38.9 degrees Celsius. The district has a high mean temperature and low degree of humidity in the summer season. This study area has an important road junction on the Madras-Dindigul National Highway (NH-45). Due to the limitations and location characteristics of the railway lines in the district, buses play a predominant role in the transport system (figure 1).

OBJECTIVES AND METHODOLOGY

The major objective of this study is to understand the transport network status in the study area using different parameters and to understand the topology pattern and road transport system in the study area. The present study entirely depends on secondary data taken from the transport department website. In the present study, quantitative, descriptive methods and cartographic techniques are used. The methods adopted in the present analysis were alpha index, beta index, gamma index, eta index and grid tree pattern index as well as network density to indicate coverage and growth, so as to identify the transport network status in the study area.

All roads including National Highway, State Highway and other roads were considered. The study area boundary was drawn using ArcGIS 9.3. In ArcGIS, the boundary and roads

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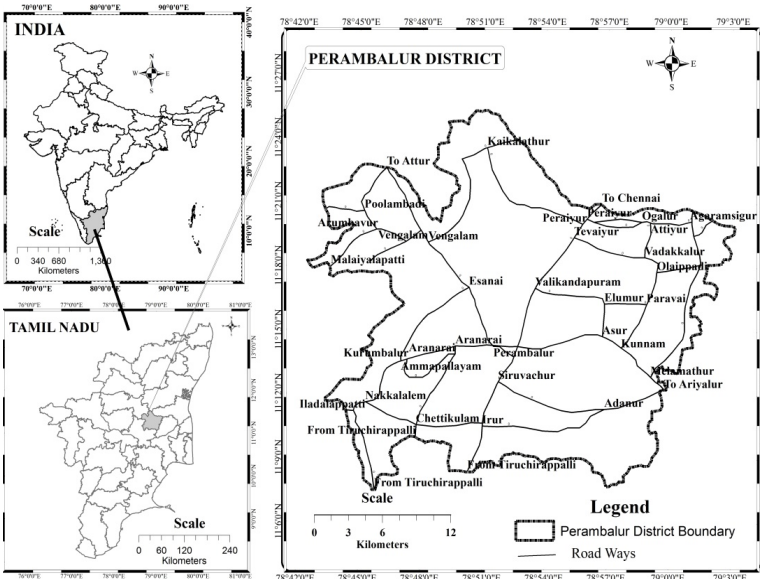

Fig. 1. *Base Map.*

were converted into polygon and polyline features respectively. The district boundaries were overlayed on the road transport system to extract the road transport system within each of the fifty-one nodes for studying the topology and development pattern of the system. The maps were prepared using ArcGIS software and the index value was calculated using MS (Microsoft) Excel.

DISCUSSION

At present, graph theory is used by geographers to describe the spatial structure of transportation networks. The network of transport happens to be a realistic feature of the geography of an area from the point of view of human interaction and is an important indicator of the level of its development (Sukla Bhaduri 1992). One of the important applications of graph theory has been its use in comparing sets of networks (Haggett 1969).

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Reducing the network road topological graph, by selecting three basic measures in a series of indices, some useful forms can be made for network comparison.

The three basic parameters, on which the indices based, are: *a*) sub-graphs; *b*) edges; *c*) vertices. Basically, networks (graphs) defined by a set of vertices and edges are of two types, namely planner and non-planner graphs. The planner graphs are defined by routes characterised by edges which do not have intersections or colon points except at the vertices. A non-planner graph is three-dimensional, and so where two edges cross each other may not necessarily be a junction. The layout and geometry of network pattern is termed as "structure" in graph theory. The graph theoretic measures applied in this study explain *a*) the layout and geometry of the transportation networks through an analysis of individual elements and characteristics and *b*) efficiency of the network structure and its comparability to measure the economic development.

Here the indices such as beta, cyclomatic number, alpha. gamma, diameter, pie, eta, theta, density of network, connectivity and accessibility are the graph theoretical indices used to measure the degree of network system in Perambalur district. All the indices are defined and discussed in detail as follows. The equations used for calculating the indices are given in table 1. Three general groups of ratio measures of use in structural analysis of the network are exposed in table 2.

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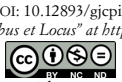

Tab. 1. *Transport System Connectivity and Coverage Measures.*

Index	Formula	Notation
Alpha Index	a= e-v+/2v-5	*e* the number of edges *v* the number of vertices
Beta Index	β= e/v	*e* the number of edges *v* the number of vertices
Gamma Index	y = e/3(v-2)	*e* the number of edges *v* the number of vertices
Cyclomatic Index	= e – v + p	*e* the number of edges *v* the number of vertices *p* the number of subgraphs
Grid Tree Proportion Index	e-v+1/(√v-1)^2	*e* the number of edges *v* the number of vertices
Pi Index	= Total Distance of Network(L)/ Distance of Diameter(A)	L length of network A the area of districts
Eta Index	= Total Network Distance (L)/ Number of Edges (E)	L the length of network E the observed number of edges
Theta Index	= Total Network Distance (L)/ Number of Vertices (V)	
Network Density	= L/A	L length of network A the area of districts
Detour Index	DI= Actual line/ Straight Line	

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Tab. 2. *Calculation of Network Connectivity Analysis Indicates.*

No. of vertices (v): 51
No. of edges (e): 55
Sub-graph (p): 01
Total length of Network: 256 sq. Km

Index	*Values*
Alpha Index	0.01
Betta Index	1.0
Gamma Index	0.4
Cyclomatic index	1.02
Pie Index	0.3
Eta index	4.6
Theta Index	5.0
Grid Tree Proportion Index	0.20
Network Density (NH &SH)	0.3
Detour Index	117

ROAD NETWORK CONNECTIVITY

Kansky (1963) studied the structure of transportation network and developed several descriptive indices for measuring the connectivity of networks, i.e. beta, gamma, alpha indices and cyclomatic number. Using Kansky's method, alpha, beta and gamma indices were calculated for measuring connectivity in the study area. A detailed description of these three indices is given below.

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Alpha Index

A more useful index of the connectivity of networks is the alpha index or "redundancy index". This consists of the ratio between the observed numbers of fundamental circuits to the maximum number of circuits that may exist in a network (Garrison, Marble 1962: 24). The observed number of fundamental circuits is given by the cyclomatic number μ while the maximum number of circuits, the division is given by 2v -*5* for planner graphs. The alpha index value will be ranging from 0 to 1.0 where 0 value represents a minimum connected network and value 1 represents a maximum connected network. For arithmetic convenience the numerical value may also be expressed in percentage. The table number 3.2 represents the alpha index calculate value is 0.01. The alpha index gives the range values possible from 0 to 1. Simple networks, such as trees, have nil values. A value of 1 is indicative of a highly integrated network in which every possible link exists between the various nodes. This value indicates the connectivity index is a medium network.

Beta Index and Betti Index

The Betti index is also referred to as cyclomatic number. It is one of the fundamental indices of graph theory and is a non-ratio measure. This index was designed so that any network with a beta index of less than 1.00 will be composed of the large branches without circuits, while a ratio of exactly 1.00 will indicate the presence of one complete circuit. A ratio of over 1.00 indicates the presence of more than one complete circuit. The values of the beta index will range from 0 to 3. It is expressed in numerical form. The beta index compares the number of links with the number of nodes in a network. The beta index calculated value is 1.0. Beta index takes 0 value when no there are no edges, 1 when the network has one circuit and more than 1 when a complicated network with several circuits is represented. In the study area, the beta index val-

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ue is more than 1 which indicates a complicated network pattern.

Gamma Index

As per K.J. Kansky, the gamma index is simply the ratio between the edges and vertices of a given transportation network. This is the ratio of the observed number of edges (e) to the maximum of edges in a planner graph. In any network, the maximum number of direct connections, is strictly a function of the number of nodes present. As the number of edges in the system decreases, the gamma index will approach one (1) as an upper limit. It appears to be most convenient to express this index as a percentage and it is therefore multiplied by 100, giving it a range from 0 to 100 and is the interpreted as per cent connected. Network connectivity as measured by the gamma index, indicates the degree by which the network deviates from an inter-connected graph and approximates in a maximally connected graph. Gamma index compares the actual number of links with the maximum possible number of links in the network. This index measures the theoretical maximum connectivity of a network. The gamma value of this study is 0.4 which expresses poor connectivity.

EFFICIENCY OF EDGES AND VERTICES

Eta Index

The Eta index is the ratio of the expressive relationship between the transportation network as a whole and its routes to the individual elements of the network. In graph theoretic measures, the Eta index is the ratio of the sum of all the edges and the vertices to the observed number of edges (Kansky 1963). A low value index has high accessibility and vice versa. This means that the network, as the value decreases over a period of time, may increase accessibility. Eta index measures the average length of a link in the network. This index is used

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as a measure of speed in the network with the assumption that the longer the segment, the better it is to ensure maximum speed in the segment. The segment value is 4.6 in this study area which indicates moderate accessibility.

Theta Index

Theta index is the ratio of the network as a whole to its vertices. It is also a measure of length of a route per vertex. The important and unique property of this index is that it gives information on the length structure and also on the degree of connectivity of the network simultaneously. Theoretically, Theta seems to be a more powerful measure than Eta and when we compare Eta and Pie, the Theta value does not change its numerical value, even when the structure of the network differs. A low value index indicates the maximum accessibility and viceversa. The index value is 5.0 which indicates moderate accessibility.

Pie Index

Pie is an index measuring the relationship between a transportation network as a whole and specific edges of that network. Pie index usually expresses the circumference of a circle and its diameter. The circumference of a circle is a function of its diameter. The total length of the network is equal to the circumference of a circle; the total length of all edges of the network is compared to the length of the diameter of a circle. The visual expression from the graph of Pie measures the "shape" of transportation networks i.e., it is a measure of length per unit of diameter. The low value of ie index indicates the ill-connected nature of networks and vice versa. Pie index is calculated using the formula as mentioned in table 1; the index value is 0.3. The value range is from 0 to 1, with higher value indicating a more connected network. These index values explain the moderate connected system in the study area.

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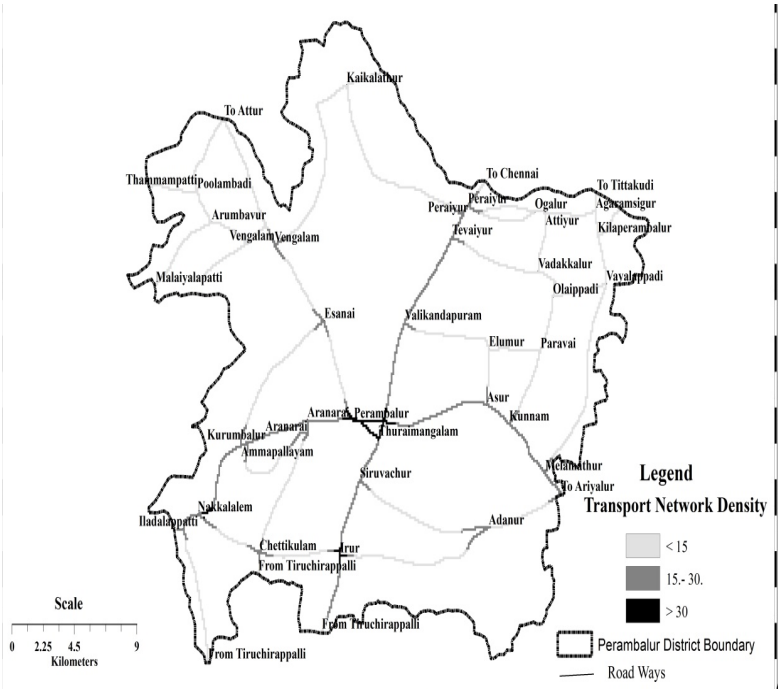

Fig. 2. *Transport Network Density in Perumbalur District.*

Network Density

Network Density is the ratio of measure of the area to the total edge length which is used to calculate the overall density per sq. km. Figure 2 represents transport network density which was high in Perambalur, Thuraimangalam, Nakkalem and Irur edges. It was moderate in Esanai, Valikandapuram, Tevaiyur, Peraiyur, Asur, Kunnam, Velamathur, Adanur, Siruvachur, Chattikulam, Aranarai, Kurumbalur, Ammapalayam, Illadalapatti and Vengalam and the remaining areas mentioned in the map were low density. The increasing density per kilometre in an area over a period of time, depicts the increasing connectivity and accessibility of network system as a whole. In this study, high density is located in the central part within population, employment and education institutions.

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Business and economic status are also high in these areas compared to other nodes.

NETWORK AS A MATRIX

Any network or abstraction of a network such as a graph is represented by a matrix. In a conventional form the horizontal routes (rows) of a matrix are identified as a set of origin nodes and the vertical columns of the matrix are defined as a set of destination nodes. The number of rows and columns in the matrix will each correspond to the total number of nodes in the network. Each cell entry in the matrix may be represented to record some formation on the relationship between a pair of nodes. The information recorded in the cells are quantitative measures. Different types of matrices are applied for varied measures of connectivity, accessibility and centrality of nodes as cell as the overall efficiency of the network (Taaffe, Gauthier 1973). The recent analysis includes: *a*) connectivity (Binary Matrix); *b*) accessibility (Konig Number); *c*) detour index.

Connectivity (Binary Matrix)

Binary Matrix shows connectivity in terms of directness. The row total equals the total number of direct linkages from a given centre to the set of all other centres in the network system. It involves the construction of a connectivity matrix in which the cell entries record the presence or absence of a linkage between each pair of nodes in the network. If a linkage exists between any given two nodes, a value of "1" is entered in the appropriate cell. If no direct linkage exists between a pair of nodes then a value of "0" is recorded. This matrix presents only minimal information about the network which is the presence or absence of direct connectivity. Hence, it is called a connectivity matrix or otherwise called a "binary matrix". Since only two things can be inferred from the matrix i.e., either presence or absence of direct connectivity between each pair, this crude

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v	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1

Fig. 3 (a). *Transport Network Connectivity Index) in Perambalur District *V – Vertices & T – Total.*

Note: 1. To Chinna Salem, 2. Kaikalathur, 3. Vengalam, 4. Vengalam East, 5. To Attur, 6. Poolambadi, 7. Vengalam, 8. Arumbavur, 9. Thondamandurai, 10. Malaiyalapatti, 11. Thammampatti, 12. Esanai, 13. Ammapallayam, 14. Kurumbalur, 15. Aranarai, 16. Aranarai, 17. Chettikulam, 18. Nakkalalem, 19, 20 & 23. From Tiruchirappalli, 21. Iladalappatti, 22. From Thuraiyur, 24 &25. Irur, 26. Siruvachur, 27. Thuraimangalam, 28. Perambalur, 29. Valikandapuram, 30. Tevaiyur, 31. Peraiyur, 32. Pennakondam, 33. Ogalur, 34. Attiyur, 35. Vadakkalur, 36. Olaippadi, 37. Vayalappadi, 38. Kilaperambalur, 39. To Avinangudi, 40. Paravai, 41. Elumur, 42. Melamathur, 43. To Ariyalur, 44. Adanur, 45. Kunnam, 46. Asur, 47. Agaramsigur, 48. To Tittakudi, 49. To Chennai, 50. Perambalur South, 51. Peraiyur.

v	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
28	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fig. 3 (b). *Transport Network Connectivity Index) in Perambalur District *V – Vertices & T – Total.*

ISSN 2283-7949
GLOCALISM: JOURNAL OF CULTURE, POLITICS AND INNOVATION
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Published online by "Globus et Locus" at https://glocalismjournal.org

v	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	T
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
12	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
16	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3

Fig. 3 (c). *Transport Network Connectivity Index) in Perambalur District *V – Vertices & T – Total.*

v	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	T
26	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3
27	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3
28	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	2
30	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
31	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3
32	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
33	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
34	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3
35	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
36	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	3
37	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3
38	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	3
39	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
40	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	3
41	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	2
42	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	3
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	2
44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3
45	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	3
46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	2
47	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	3
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
50	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3
51	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3

Fig. 3 (d). *Transport Network Connectivity Index) in Perambalur District *V – Vertices & T – Total.*

ISSN 2283-7949
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Published online by "Globus et Locus" at https://glocalismjournal.org

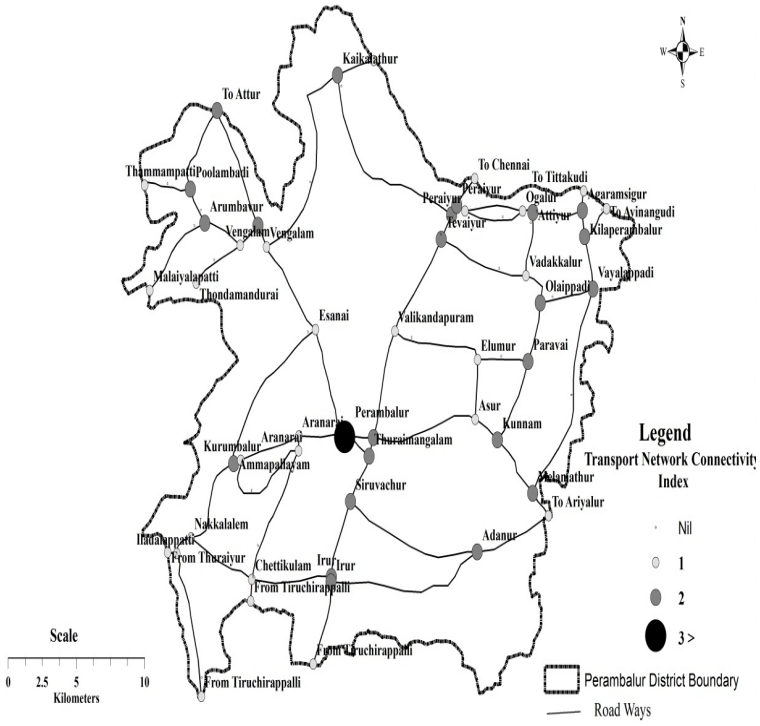

Fig. 4. *Transport network Connectivity Index in Perambalur District*.

measure of the degree of connectivity can be improved by means of addition of links between disconnected places. The connectivity values were classified based on nodes; then thematic map was created and indicated by pointing buffering symbols.

The connectivity or binary matrix of the road network in Perambalur district has been analysed which is represented in the given figure 3 (a) and 3 (b) and figure 4. The binary matrix or connectivity matrix had revealed that Perambalur town was the most connected settlement having four direct connections followed by Kaikalathur, Vengalam East, To Attur, Poolambadi, Arumbavur, Ammapallayam, Irur, Siruvachur, Thuraimangalam, Tevaiyur, Peraiyur, Attiyur, Olaippadi, Vayalappadi, Kilaperambalur, Paravai, Melamathur, Adanur, Kunnam, Agaramsigur, Perambalur south and Peraiyur which

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	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	0	1	2	3	4	5	4	5	5	6	6	3	4	5	6	5	7	5	8	7	5	7	9	8	7	6
2	1	0	1	2	3	5	3	4	4	5	6	2	3	5	5	4	6	4	7	6	5	6	9	7	6	5
3	2	1	0	1	2	3	2	3	3	3	5	1	2	3	4	3	5	3	6	5	4	5	7	6	5	4
4	3	2	1	0	1	2	1	2	2	2	4	2	3	4	5	4	6	4	7	6	5	6	8	7	6	5
5	4	3	2	1	0	1	2	2	4	4	2	3	4	5	6	5	7	5	8	7	6	7	9	8	7	6
6	5	5	3	2	1	0	2	1	3	2	1	5	6	7	8	7	9	7	10	9	8	9	11	10	9	8
7	4	3	2	1	2	2	0	1	1	2	3	3	4	5	6	5	7	5	8	7	6	7	9	8	7	6
8	5	4	3	2	2	1	1	0	2	1	2	4	5	6	7	6	8	6	9	8	7	8	10	9	8	7
9	5	4	3	2	4	3	1	2	0	2	4	4	5	6	7	6	8	6	9	8	7	8	10	9	8	7
10	6	5	3	2	4	2	2	1	2	0	3	5	6	7	8	7	9	7	10	9	8	9	11	10	9	8
11	6	6	5	4	2	1	3	2	4	3	0	6	7	8	9	8	10	8	11	10	9	10	12	11	10	9
12	3	2	1	2	3	5	3	4	4	5	6	0	4	5	4	6	4	7	6	5	6	8	7	6	5	4
13	4	3	2	3	4	6	4	5	5	6	7	4	0	1	3	2	3	1	3	3	2	3	5	4	7	6
14	5	5	3	4	5	7	5	6	6	7	8	5	1	0	1	1	2	2	3	5	2	3	6	5	8	7
15	6	5	4	5	6	8	6	7	7	8	9	4	3	1	0	1	1	1	2	4	1	2	5	4	7	6
16	5	4	3	4	5	7	5	6	6	7	8	6	2	1	1	0	2	3	3	5	4	5	5	4	3	4
17	7	6	5	6	7	9	7	8	8	9	10	4	3	2	1	2	0	1	1	3	3	4	3	2	1	2
18	5	4	3	4	5	7	5	6	6	7	8	7	1	2	1	3	1	0	2	1	2	1	4	3	2	3
19	8	7	6	7	8	10	8	9	9	10	11	6	3	3	2	3	1	2	0	4	4	5	4	3	2	3
20	7	6	5	6	7	9	7	8	8	9	10	5	3	5	4	5	3	1	4	0	6	5	4	5	6	7
21	5	5	4	5	6	8	6	7	7	8	9	6	2	2	1	4	3	2	4	1	0	1	5	4	3	4
22	7	6	5	6	7	9	7	8	8	9	10	8	3	3	2	5	4	1	5	1	1	0	6	5	4	5
23	9	9	7	8	9	11	9	10	10	11	12	7	5	6	5	5	3	4	4	6	5	6	0	1	1	2
24	8	7	6	7	8	10	8	9	9	10	11	6	4	5	4	4	2	3	3	5	4	5	1	0	1	1

Fig. 5 (a). *Transport Network Accessibility Index (Koing Index) in Perambalur District *V – Vertices & T – Total.*

Note: 1. To Chinna Salem, 2. Kaikalathur, 3. Vengalam, 4. Vengalam East, 5. To Attur, 6. Poolambadi, 7. Vengalam, 8. Arumbavur, 9. Thondamandurai, 10. Malaiyalapatti, 11. Thammampatti, 12. Esanai, 13. Ammapallayam, 14. Kurumbalur, 15. Aranarai, 16. Aranarai, 17. Chettikulam, 18. Nakkalalem, 19, 20 & 23. From Tiruchirappalli, 21. Iladalappatti, 22. From Thuraiyur, 24 &25 . Irur, 26. Siruvachur, 27. Thuraimangalam, 28. Perambalur, 29. Valikandapuram, 30. Tevaiyur, 31. Peraiyur, 32. Pennakondam, 33. Ogalur, 34. Attiyur, 35. Vadakkalur, 36. Olaippadi, 37. Vayalappadi, 38. Kilaperambalur, 39. To Avinangudi, 40. Paravai, 41. Elumur, 42. Melamathur, 43. To Ariyalur, 44. Adanur, 45. Kunnam, 46. Asur, 47. Agaramsigur, 48. To Tittakudi, 49. To Chennai, 50. Perambalur South, 51. Peraiyur.

had moderate connectivity. In contrast, Vengalam, Thammampatti, Esanai, Kurumbalur, Aranarai, Chettikulam, Nakkalalem, Iladalappatti, Valikandapuram, Pennakondam, Ogalur, Vadakkalur, Elumur, Ariyalur and Asur had low connectivity and the remaining places had very low connectivity (figure 4). In this study area, the connectivity value indicated that main centre node is Perambalur.

ISSN 2283-7949
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V	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
25	7	6	5	6	7	9	7	8	8	9	10	5	7	8	7	3	1	2	2	4	3	4	1	1	0	1
26	6	5	4	5	6	8	6	7	7	8	9	4	6	7	6	4	2	3	3	5	4	5	2	1	1	0
27	5	4	3	4	5	7	5	6	6	7	8	3	5	6	5	3	3	4	4	6	5	6	3	2	1	1
28	4	3	2	3	4	6	4	5	5	6	7	6	3	4	3	2	3	5	4	7	6	7	5	4	3	3
29	4	3	5	6	7	9	7	8	8	9	10	5	6	7	6	4	5	6	6	8	7	8	5	4	3	3
30	3	2	4	5	6	8	6	7	7	8	9	3	7	8	7	5	6	7	7	9	8	9	6	5	4	4
31	2	1	2	3	4	6	4	5	5	6	7	4	8	9	8	6	7	8	8	10	9	10	7	6	5	5
32	3	2	3	4	5	7	5	6	6	7	8	5	9	10	9	7	8	9	9	11	10	11	8	7	6	6
33	4	3	4	5	6	8	6	7	7	8	9	6	10	11	10	8	9	10	10	12	11	12	9	8	7	7
34	5	4	5	6	7	8	7	8	8	9	9	5	11	12	11	9	10	11	11	13	12	13	10	9	8	8
35	3	2	4	5	6	7	6	7	7	8	8	6	8	9	8	6	7	8	8	10	9	10	7	6	5	8
36	4	3	5	6	7	9	7	8	8	9	10	7	9	10	9	7	8	9	9	11	10	11	8	7	6	6
37	5	4	6	7	8	10	8	9	9	10	11	8	10	11	10	8	9	9	10	11	10	11	9	8	7	7
38	6	5	7	8	9	11	9	10	10	11	12	9	11	12	11	9	9	11	10	13	12	13	10	9	8	8
39	8	7	8	9	10	12	10	11	11	12	13	8	12	13	12	10	10	12	11	14	13	14	11	10	9	9
40	5	4	7	8	9	11	9	10	10	11	12	7	8	9	8	7	6	8	7	10	9	10	7	6	5	5
41	5	4	6	7	8	10	8	9	9	10	11	8	7	8	7	5	5	7	6	9	8	9	6	5	4	4
42	7	6	7	8	9	11	9	10	10	11	12	9	7	8	7	6	6	9	7	11	10	11	9	8	7	6
43	8	7	8	9	10	12	10	11	11	12	13	6	8	9	8	7	7	10	8	12	11	12	10	2	2	7
44	6	5	5	6	7	9	7	8	8	9	10	7	7	8	7	6	5	11	6	13	12	13	8	1	1	2
45	6	5	6	7	8	10	8	9	9	10	11	6	6	7	6	3	5	8	6	10	9	10	8	7	6	6
46	5	4	5	6	7	9	7	8	8	9	10	8	5	6	5	2	4	7	5	9	8	9	7	6	5	5
47	5	4	7	8	9	11	9	10	10	11	12	9	12	13	12	8	9	12	10	14	13	14	11	10	9	10
48	6	5	8	9	10	12	10	11	11	12	13	5	13	14	13	9	10	13	11	15	14	15	12	11	10	11
49	3	2	4	5	6	8	6	7	7	8	9	4	9	10	9	8	6	10	7	12	11	12	8	7	6	6
50	5	4	3	4	5	7	5	6	6	7	8	4	4	5	4	3	3	6	4	8	7	8	6	5	4	3
51	3	2	3	4	5	7	5	6	6	7	8	1	9	10	9	7	7	9	8	11	10	11	7	6	5	7

Fig. 5 (b). *Transport Network Accessibility Index (Koing Index) in Perambalur District*
**V – Vertices & T – Total.*

V	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	T
1	5	4	4	3	1	3	4	5	3	4	5	6	8	5	5	7	8	6	6	5	5	6	3	5	3	252
2	4	3	3	2	1	2	3	4	2	3	4	5	7	4	4	6	7	5	5	4	4	5	2	4	2	209
3	3	2	5	4	2	3	4	5	4	5	6	7	8	7	6	7	8	5	6	5	7	8	4	3	3	215
4	4	3	6	5	3	4	5	6	5	6	7	8	9	8	7	8	9	6	7	6	8	9	5	4	4	250
5	5	4	7	6	4	5	6	7	6	7	8	9	10	9	8	9	10	7	8	7	9	10	6	5	5	295
6	7	6	9	8	6	7	8	8	7	9	10	11	12	11	10	11	12	9	10	9	11	12	8	7	7	373
7	5	4	7	6	4	5	6	7	6	7	8	9	10	9	8	9	10	7	8	7	9	10	6	5	5	291
8	6	5	8	7	5	6	7	8	7	8	9	10	11	10	9	10	11	8	9	8	10	11	7	6	6	333
9	6	5	8	7	5	6	7	8	7	8	9	10	11	10	9	10	11	8	9	8	10	11	7	6	6	340
10	7	6	9	8	6	7	8	9	8	9	10	11	12	11	10	11	12	9	10	9	11	12	8	7	7	380
11	8	7	10	9	7	8	9	9	8	10	11	12	13	12	11	12	13	10	11	10	12	13	9	8	8	424
12	3	6	5	3	4	5	6	5	6	7	8	9	8	7	8	9	6	7	6	8	9	5	4	4	1	264
13	5	3	6	7	8	9	10	11	8	9	10	11	12	8	7	7	8	7	6	5	12	13	9	4	9	300
14	6	4	7	8	9	10	11	12	9	10	11	12	13	9	8	8	9	8	7	6	13	14	10	5	10	341
15	5	3	6	7	8	9	10	11	8	9	10	11	12	8	7	7	8	7	6	5	12	13	9	4	9	317
16	3	2	4	5	6	7	8	9	6	7	8	9	10	7	5	6	7	6	3	2	8	9	8	3	7	263
17	3	3	5	6	7	8	9	10	7	8	9	9	10	6	5	6	7	5	5	4	9	10	6	3	7	281
18	4	5	6	7	8	9	10	11	8	9	9	11	12	8	7	9	10	11	8	7	12	13	10	6	9	312
19	4	4	6	7	8	9	10	11	8	9	10	10	11	7	6	7	8	6	6	5	10	11	7	4	8	330
20	8	9	10	11	12	13	10	11	11	13	14	10	9	11	12	13	10	9	14	15	12	8	11			401
21	5	6	7	8	9	10	11	12	9	10	10	12	13	9	8	10	11	12	9	8	13	14	11	7	10	356
22	6	7	8	9	10	11	12	13	10	11	11	13	14	10	9	11	12	13	10	9	14	15	12	8	11	404
23	3	5	5	6	7	8	9	10	7	8	9	10	11	7	6	9	10	8	8	7	11	12	8	6	7	362
24	2	4	4	5	6	7	8	9	6	7	8	9	10	6	5	8	2	1	7	6	10	11	7	5	6	300

Fig. 5 (c). *Transport Network Accessibility Index (Koing Index) in Perambalur District*
**V – Vertices & T – Total.*

ISSN 2283-7949
GLOCALISM: JOURNAL OF CULTURE, POLITICS AND INNOVATION
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Published online by "Globus et Locus" at https://glocalismjournal.org

V	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	T
25	1	3	3	4	5	6	7	8	5	6	7	8	9	5	4	7	2	1	6	5	9	10	6	4	5	267
26	1	3	3	4	5	6	7	8	8	6	7	8	9	5	4	6	7	2	6	5	10	11	6	3	7	271
27	0	2	5	6	7	8	9	10	7	8	9	10	11	7	6	6	7	6	5	4	11	12	8	3	8	292
28	2	0	2	3	4	5	6	7	7	5	6	7	8	4	3	5	2	1	5	4	9	10	5	2	6	232
29	2	5	0	1	2	3	4	5	2	3	4	5	6	2	1	4	5	6	3	2	7	8	4	1	3	247
30	3	6	1	0	1	2	3	4	1	2	3	4	5	3	2	5	6	3	4	3	5	6	3	2	4	241
31	4	7	2	1	0	1	3	4	3	4	5	6	7	4	3	5	6	7	4	3	4	5	2	3	2	250
32	5	8	3	2	1	0	1	2	3	4	5	6	5	7	6	8	9	7	7	6	4	5	2	5	1	293
33	6	9	4	3	3	1	0	1	2	3	4	3	4	5	5	6	7	8	4	5	3	4	2	6	1	306
34	7	10	5	4	4	2	1	0	1	2	3	2	3	4	5	6	7	8	5	6	2	3	4	5	2	330
35	7	7	2	1	3	3	2	1	0	1	2	3	4	3	4	5	6	7	3	4	3	4	5	4	5	267
36	5	8	3	2	4	4	3	2	1	0	1	2	3	1	2	3	4	5	2	3	3	4	6	4	5	283
37	6	9	4	3	5	5	4	3	2	1	0	1	2	2	4	1	3	5	3	4	3	4	7	6	6	318
38	7	10	5	4	6	6	3	2	3	2	1	0	1	3	4	2	3	4	3	4	1	2	6	7	5	347
39	8	11	6	5	7	5	4	3	4	3	2	1	0	4	5	3	4	5	4	5	2	3	7	8	6	394
40	4	7	2	3	4	7	5	4	3	1	2	3	4	0	1	2	3	4	1	2	5	6	6	4	5	296
41	3	6	1	2	3	6	5	5	4	2	4	4	5	1	0	4	5	6	2	1	5	6	5	2	4	276
42	5	6	4	5	5	8	6	6	5	3	1	2	3	2	4	0	1	2	1	2	3	4	8	3	7	317
43	2	7	5	6	6	9	7	7	6	4	3	3	4	3	5	1	0	1	2	3	4	5	9	4	8	344
44	1	6	6	3	7	7	8	8	7	5	5	4	5	4	6	2	1	0	3	4	5	6	10	5	9	314
45	5	5	3	4	4	7	4	5	3	2	3	3	4	1	2	1	2	3	0	1	5	6	7	2	6	280
46	4	4	2	3	3	6	5	6	4	3	4	4	5	2	1	2	3	4	1	0	6	7	6	1	5	260
47	9	11	7	5	4	4	3	2	3	3	3	1	2	5	5	3	4	5	5	6	0	1	5	6	4	368
48	10	12	8	6	5	5	4	3	4	4	4	2	3	6	6	4	5	6	6	7	1	0	6	7	4	411
49	5	8	4	3	2	2	2	4	5	6	7	6	7	6	5	8	9	10	7	6	5	6	0	4	1	318
50	2	3	1	2	3	5	6	5	4	4	6	7	8	4	2	3	4	5	2	1	6	7	4	0	4	232
51	6	8	3	4	2	1	1	2	5	5	6	5	6	5	4	7	8	9	6	5	4	4	1	4	0	284

Fig. 5 (d). *Transport Network Accessibility Index (Koing Index) in Perambalur District*
V – Vertices & T – Total.

Accessibility Index (Konig Number)

The degree of centrality of any point or node on a network may be described by its Konig number (developed by D. Konig in 1936) This is given by the maximum number of edges from any given vertex by the shortest path to any other vertex in the network, i.e., maximum number of edges in each column in the shortest path matrix. The lowest Konig number indicates the most central node of the given road network. The Konig number is also called "associated number".

In this study, the distribution of accessibility (figure 6) or Konig matrix has revealed that Kaikalathur, Vengalam, Perambalur, Perambalur South, Tevaiyur, Valikandapuram, Vengalam East, Peraiyur, Chinna Salem, Asur, Aranarai, Esanai, Irur, Vadakkalur, Siruvachur, Elumur and Kunnam had the lowest accessibility in these places with the most central node of the road network districts. While Chettikulam, Olaippadi, Peraiyur, Vengalam, Thuraimangalam, Pennakondam, Attur, Paravai, Ammapallayam, Irur, Ogalur, Nakkalalem, Adanur, Aranarai, Melamathur, and Vayalappadi have

ISSN 2283-7949
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Published online by "Globus et Locus" at https://glocalismjournal.org

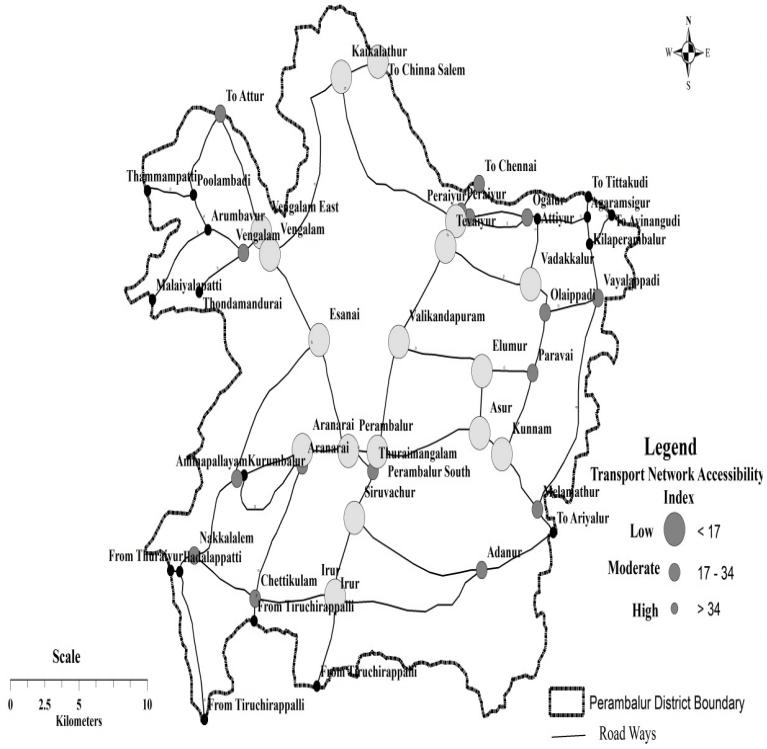

Fig. 6. *Transport Network Accessibility Index in Perambalur District.*

comprised the highest accessibility with the least centrality of the vertices.

It is significant to state that the centrality of low accessibility towns is due to their peripheral location on the road network in the district. The moderate accessibility in the remaining places was observed as being due to the location of nodes in the central part of the district and urbanisation.

DETOUR INDEX

The detour index of directness in a way is complementary to the topological description of graph theory (Cole, King

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GLOCALISM: JOURNAL OF CULTURE, POLITICS AND INNOVATION
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Published online by "Globus et Locus" at https://glocalismjournal.org

1968). The overall detour indices should help us to characterise the efficiency of transportation networks (Warntz 1967). The ideal path between two vertices is the direct distance. If a transport system has more direct distances for all places, the path is said to be seldom achieved and is said to have a more efficient network system. The direct linkages from a given place (vertex) to other places (vertices) is known as the degree of nodal efficiency. The distance matrix can be used to indicate the nodal efficiency of the transport system. It measures the efficiency of a node in terms of directness by calculating the vertex detour index.

The detour index expresses the actual journey involved as a percentage of the direct or desire line distance. It is found that the actual journey distance is always greater than the desire line distance. The vertex detour index is always greater than 100. It represents that the higher the detour index, the lesser the directness of the route from a given vertex to the other, and vice versa. It means low efficiency of network in high values of detour index in terms of directness and more efficiency in low values of detour index.

The computation procedure involves three types of matrices: *a*) shortest path matrix; *b*) desire line matrix; *c*) detour index matrix. The shortest path matrix (distance matrix) brings out a simple study of relationship between places. The distance from each of the places to other places is noted in the shortest road distance matrix (table 3). This matrix results in some relevant factors. *a*) Each row gives the details of distance of a particular node to every other node, from which the nearest place for a centre can be located by tracing the lowest value; and *b*) from the row total it is possible to analyse the degree of accessibility. The lower the value of the sum, the higher the accessibility. The desire line matrix (table 3) represents the distance in terms of direct distances. The straight-line distance from each vertex to other can be observed from this matrix. The directness of the road determines the speed and time of travel. After observing the shortest path matrix of the road network of Perambalur district, the following conclusions are made (table 3).

ISSN 2283-7949
GLOCALISM: JOURNAL OF CULTURE, POLITICS AND INNOVATION
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Tab. 3. *Actual, Straight line in Kilometer and Detour Index* *

V*	Name	Actual Line	Straight Line	Detour Index	V*	Name	Actual Line	Straight Line	Detour Index
1	Chinna Salem	1662	1217.1	137	27	Thuraimangalam	1042.8	858	122
2	Kaikalathur	1515	1070.1	142	28	Perambalur	1144.44	806.7	142
3	Vengalam	1316.4	1030.8	128	29	Valikandapuram	1145.76	990	116
4	Vengalam East	1355.1	1073.3	126	30	Tevaiyur	1095.96	979.5	112
5	Attur	1635.3	1367.7	120	31	Peraiyur	1143.9	960.3	119
6	Poolambadi	1664.4	1328.7	125	32	Pennakondam	1187.22	983.4	121
7	Vengalam	1404.6	1131.7	124	33	Ogalur	1368.9	1200.6	114
8	Arumbavur	1518.9	1248	122	34	Attiyur	1400.4	1258.5	111
9	Thondamandurai	1591.5	1333.8	119	35	Vadakkalur	1374.3	1102.5	125
10	Malaiyalapatti	1818.9	1536.3	118	36	Olaippadi	1458	1134.3	129
11	Thammampatti	1897.2	1474.2	129	37	Vayalappadi	1531.5	1306.5	117
12	Esanai	1120.8	958.2	117	38	Kilaperambalur	1469.1	1420.8	103
13	Ammapallayam	1078.5	1149.6	94	39	To Avinangudi	1586.7	1536.6	103
14	Kurumbalur	1097.7	1179	93	40	Paravai	1470.6	1281	115
15	Aranarai	1290.3	1294.8	100	41	Elumur	1353.3	1153.2	117
16	Aranarai	1289.4	1338.3	96	42	Melamathur	1583.1	1290.9	123
17	Chettikulam	1503.6	1217.4	124	43	To Ariyalur	1657.5	1369.5	121
18	Nakkalalem	1622.7	1340.4	121	44	Adanur	1597.5	1287	124
19	Tiruchirappalli	1511.1	1261.5	120	45	Kunnam	1390.2	1145.4	121
20	Tiruchirappalli	2075.1	1705.5	122	46	Asur	1393.8	1066.2	131
21	Iladalappatti	1697.1	1381.8	123	47	Agaramsigur	1428	1413.9	101
22	Thuraiyur	1735.2	1370.1	127	48	To Tittakudi	1464.39	1483.5	99
23	Tiruchirappalli	1386.51	1281.6	108	49	To Chennai	1245.9	1063.2	117
24	Irur	1182.81	1061.7	111	50	Perambalur South	917.7	873.6	105
25	Irur	1164	1045.8	111	51	Peraiyur	1158.39	976.5	119
26	Siruvachur	1034.1	946.5	109		Total	71777.6	61285.5	117

Perambalur node is identified as the nearest place to all other places (actual distance is 917.7 Kms) followed by Siruvachur (1034.1 Kms), Thuraimangalam (1042.8 Kms.), Amma-

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pallayam (1078.5 Kms.), Tevaiyur (actual distance is 1095.96 Kms.), Kurumbalur (1097.7 Kms.), Esanai (1120.8 Kms.), Peraiyur (actual distance is 1143.9 Kms.), Valikandapuram (1145.76 Kms.), Irur (1164 Kms.), and Pennakondam (1187.22 Kms.). The above said nodes are located in the central part of the district. These are the nodes possessing close proximity to all nodes than the other vertices. It indicates that the time taken to travel may be less from these nodes to other nodes.

The most distant places are Thammampatti (1897.2), Malaiyalapatti (1818.9 Kms.), Iladalappatti (1697.1 Kms.), Poolambadi (1664.4 Kms.), Nakkalalem (1622.7 Kms.), Adanur (1597.5 Kms.), Thondamandurai (1591.5 Kms.), Melamathur (1583.1 Kms.), Vayalappadi (1531.5 Kms.), Arumbavur (1518.9 Kms.), Kaikalathur (1515 Kms.), Chettikulam (1503.6 Kms.), Paravai (1470.6 Kms.), Kilaperambalur (1469.1 Kms.) and Olaippadi (1458). These places are peripheral in their location i.e., distributed in different corners of the district and located very far away from the other places.

The straight-line distance matrix (desire line matrix) revealed the following facts. The desire line matrix differs from the shortest path matrix. Perambalur (806.7 Kms.) is the most accessible settlement in terms of directness followed by Thuraimangalam 858, Siruvachur (946.5 Km.), Esanai (958.2 Km.), Peraiyur (960.3 Km.), Tevaiyur (979.5 Km.), Pennakondam (983.4 Km.), Valikandapuram (990 Km.), Vengalam (1030.8 Km.), Irur (1045.8 Km.), Asur (1066.2 Km.), Kaikalathur (1070.1 Km.), Vadakkalur (1102.5 Km.). The abovementioned nodes are centrally located in the study area and have high connectivity both in the shortest path matrix and desire line matrix. This matrix also shows that Malaiyalapatti (1536.3 Kms.), Thammampatti (1474.2 Km.), Kilaperambalur (1420.8 Km.), Agaramsigur (1413.9 Km.), Iladalappatti (1381.8 Km.), Nakkalalem (1340.4 Km.), Aranarai (1338.3 Km.), Thondamandurai (1333.8 Km.), Poolambadi (1328.7 Km.), Vayalappadi (1306.5 Km.), Aranarai (1294.8 Km..), Melamathur (1290.9 Km..), Adanur (1287 Km.), Paravai (1281 Km.) and Attiyur (1258.5 Km) are located far away from the other places and more particularly in the different corners of the district.

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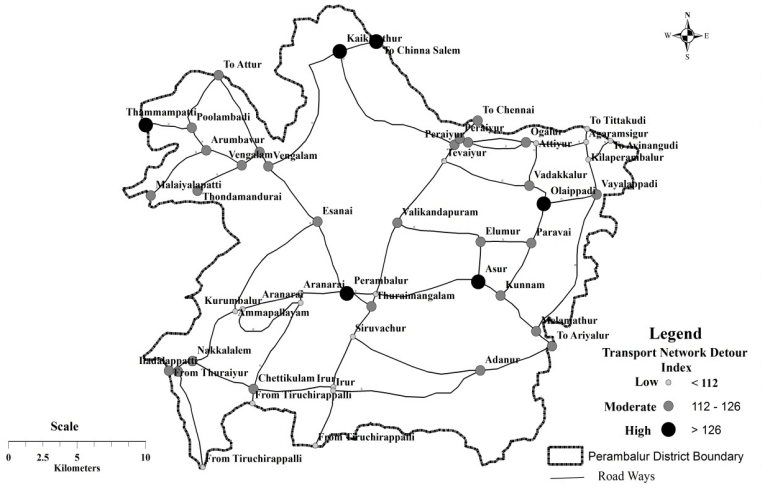

Fig. 7. *Transport Network Detour Index in Perambalur District.*

The detour matrix which is computed on the basis of actual road distance and desire line distance revealed the order of efficiency of nodes having efficient road network to save the journey time and transport cost from one node to another. The vertex demur index has been computed for 51 nodes. It shows that there has been a significant variation in the degree of directness of the nodes in the present study. It is noted that the detour index value ranged between 93 and 142. Out of all the nodes, Kurumbalur, Ammapallayam, and Aranarai have the least detour index value of below 100, which indicates the higher nodal efficiency in saving journey time compared with all the other nodes in the district. In contrast, Perambalur, Kaikalathur, Asur, Thammampatti, Olaippadi and Vengalam have high detour index values indicating low nodal efficiency. The mean vertex detour index for 51 settlements has 117 nodes among which 23 nodes has lesser mean detour index value. It may be stated that 45 per cent of the total nodes in the district possessed the least efficiency of nodes in terms of directness. It is significant to note that Perambalur district which is endowed with plateau and dry regional form of topography has

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a greater impact on road transportation network besides locational aspects of the settlements distribution as an important factor.

From the figure 7 we see that the transport network detour index value was high in (>126) Perambalur (142), Kaikalathur (142), Asur (131), Thammampatti (129), Olaippadi (129), Vengalam (128) node of the district. The low detour index areas (<112) are found in the western, eastern and southern sides of the district. The moderate detour index areas (115-121) are found in central parts of the district. The detour values clearly indicate the nature of the district's terrain. Many of the nodes with high detour values represent the rugged terrain of the district. From the above analysis it is inferred that the transportation network in terms of directness has been much influenced by physiography and spatial distribution of some of the important settlements in the district (figure 7).

CONCLUSION

A relative measure to an analysis of the network configuration is based on the value of alpha and gamma indices. Three basic network configurations are spinal, grid and delta (Taaffe 1974). The spinal pattern is characteristic of a minimally connected network. Every node is connected to at least one another node on the network and it is possible for flow to occur between any two nodes in the network, but only by a single path. The total geographical area of the district is 1752 sq. Kms. In this study area, it consists of 51 vertices and 55 edges. It has formed the cyclomatic number of about 1. The Beta value of 1 denotes that the network is less connected. Similarly, the low value of Alpha (0.01) index clearly indicates the lesser degree of connectivity of the road network of Perambalur district. The gamma index is medium (0.4) also indicating the lesser degree of connectivity. The value Alpha (0.01) and Gamma (0.4) are indicating the grid pattern of road network configuration. The Pie value (0.3) of the road network size has determined it as a less compact one. The medi-

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um values of Theta (5.0) and Eta (4.6) are showing the low connectivity and moderate accessibility of road network. The centre part of the district has a higher density than the surrounding districts. The low density of road and route length within the district reveals the low degree of connectivity and accessibility. The medial part of the districts connectivity is high and other places moderate and low. The accessibility index is low and the connecting vertices distance is low within other vertices. From Perambalur towns to other vertices places the distance is low and can be connected to the all other vertices very easily. From this total parameter assessment, it is concluded that the transport network pattern is good in Perambalur Town compared to other nodes.

These measures presented here consider some aspects of transport network analysis. Future extension to the present analysis includes the topology aspect of the network.

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GLOCALISM: JOURNAL OF CULTURE, POLITICS AND INNOVATION
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