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Urban Road Network Connectivity Analysis Based on Gis for Aurangabad City, Maharashtra

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ABSTRACT
Urban road network plays an important role in urban local network. The urban road network plays a key role in the urban spatial structure. It is the main city social-economy activities and transportation carrier. An important event of the cultural landscape is that transportation serves as a powerful factor in regional as well as national development. In connectivity network analysis, the term connectivity is known as the quantity of connections between nodes in a given network, so it derives the structure of the road network. Road network, major junctions, retail junctions, major corridors, road density and connectivity can be analyzed using the network connectivity indicators on the GIS platform. Road network dataset is created in ArcGIS which provides the number of transport lines and number of Junctions in study region. One of the most basic features of a transportation network is the network index, such as the alpha, beta, gamma index, etc. There are various indices, and each index has its individual equation for different purposes. It requires road network (line), junction (nodes) to draw connectivity index. Roads density is highest in most of the zones in Aurangabad city and lowest road density recorded in zone A in the north and E is south-west direction. he averages score of the gamma index has been increased from 0.50 in 2001 to 0.53 in 2011 where the average value also increased from 0.44 to 0.48 during this period.

KEY WORD: Road connectivity, Road Density, Geospatial, Alpha, Beta, Gamma Index

1. INTRODUCTION

The urban road network plays a key role in the urban spatial structure. It is the main city social-economy activities and transportation carrier. Connectivity is the density of connections and direct links in a path or road network. The transportation system is a critical component of urban infrastructural development and economic growth of the city. The interrelationships between urban extension and road network characteristics provide important context for the future development of global cities. Graph theory is a branch of mathematics that deals with how networks can be encoded and measure their properties. Indicators showing the specific components of the network, the number of basic circuits, the number of circuits and the maximum number of edges / vertices monitored. Indexes that represent the relationship between the entire network and one of its individual components of the whole edge. The solutions that describe the transport network are constructed entirely as a ratio between the entire system and its individual components. The only two solutions, abstracted directly from graph theory (Cyclomatic numbers and diameters) are non-ratio solutions. Non-standard solutions are not appropriate when compared to different networks. The standard of living of a citizen depends heavily on the efficiency and

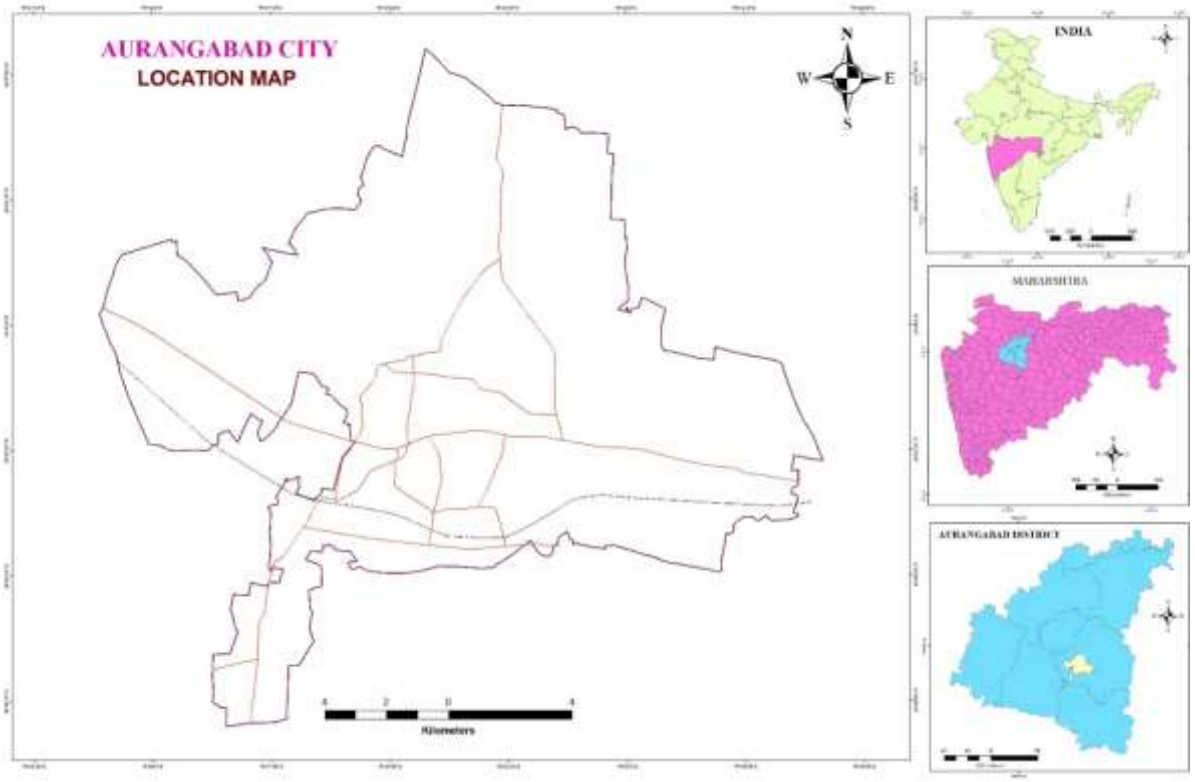
effectiveness of its road network connectivity in the region. The real goal of the urban road network is to access and link places, facilities, utilities and services, etc.

2. STUDY AREA

Geographical location of the Aurangabad Municipal Corporation between 19º 53'59'' north latitude and 75º 22'46'' East longitude. The Aurangabad city has situated from mean sea level of 581Mts. It is a district and divisional headquarter located on the Kham river. The city of Aurangabad situated on the Deccan trap stand by the Dudhna valley between the Lakhwara ranges of the northern side and satara hills are located in southern part of the city. Aurangabad municipal corporation was ''A'' class municipal council it's having area about 54.4 Sq. Km in 1982. Then municipal council converts into Municipal Corporation in 1982 Additional 18 villages including corporation. It is having area of the 138.50 Sq. The Aurangabad city has been situated on the Manmad-Hydrabad broad gauge railway line. This city is well connected by the district headquarters of Maharashtra state and major cities. Aurangabad city is good connectivity by airways and road network.

3. AIMS AND OBJECTIVE

1. To study of road network density of Aurangabad city.
2. To evaluate road network connectivity in Aurangabad city.
3. To analyze the GIS based road Network in Aurangabad city.



4. MATERIAL AND METHOD

The methodology deals with the various methods adopted to the road network information in study area. Prepare the base map of survey of India SOI Toposheet no.47 E/7, and boundary map of city collect from Municipal Corporation. A Google earth satellite imagery, which was geo-referenced in ArcGIS, was used

for the network analysis of the Aurangabad city. The current and exiting road network of the Aurangabad city digitized on google earth pro from 2001 and 2011. Google earth kml file import and convert into shape file using ArcGIS 10.2 software. Geodatabase is part of the Geographic Information System (GIS) which helps in collecting and manipulating geographic data. Network dataset analyst of ArcGIS 10.2 was used to generate nodes and edges, from which connectivity indices were evaluated for all zone.

SOFTWARE USED

1. ArcGIS 10.2
2. Google Earth pro

Sr. No	Data Used	Spatial Reference	Source
1	Toposheet no.47 E/7	1:50,000	Survey of India
2	Cadastral map	Not to scale	Aurangabad municipal corporation

1. Road Density

$$\text{Road Density} = \frac{\text{Total Length of Road}}{\text{Total Area in Sq. km}}$$

It is shows the high road density higher the development of road network

2. Alpha Index

$$\text{Alpha Index } \propto = \frac{E-V+1}{2V-5}$$

Where e is the number of segments (edges) and v is the number of nodes in the network.

3. Beta Index

$$Beta\ Index\ \beta = \frac{E}{V}$$

The beta index is the simplest form of the measure of Road network connectivity Where e is the number of segments (edges) and v is the number of nodes in the network.

4. Gamma Index

Gamma index measures the theoretic maximum connectivity of a road network. The gamma index is a simple ratio of actual number of edges in the network to the maximum possible number of edges.

$$Gamma\ Index\ \gamma = \frac{E}{3(V-2)}$$

Where e denotes number of segment (edges) and v is the number of nodes in transport network. (Gavu Kofi, 2010)

5. RESULT AND DISCUSSION

5.1 SPATIAL PATTERNS OF THE ROAD NETWORK CONNECTIVITY.

The road network connectivity distribution of Aurangabad city in 2001 and 2011 was taken as the case study. Spatial distribution patterns of road networks connectivity are created based on line density estimation models using ArcGIS software (figure.2). The line density in the city is distributed in a total no of four categories including the very lowest, lowest, moderate and highest line density. It was revealed that the road network distribution is uneven throughout the city, and the focus is clearly on the center of the city, then gradually spreading to the perimeter from the center of the city. There is no doubt that the

oldest area of the city has the highest road network density, which was distributed in zones B, C and D in 2011. Comparatively road network connectivity of the two periods, it is clear that the increasing rate of road development has definitely improved in the period 2001-2011.

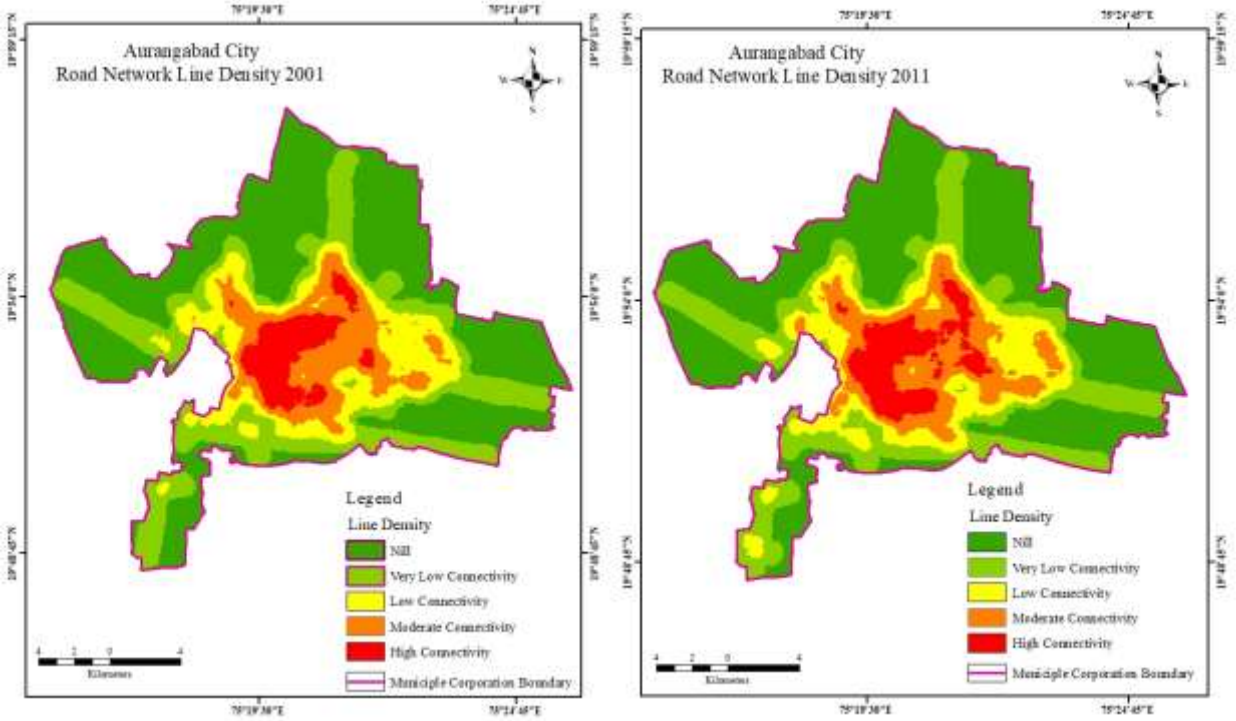


Figure.2

5.2 ROAD NETWORK CONNECTIVITY ANALYSIS USING GRAPH THEORY

The topological structure of the road network is an important factor in shaping the city. Assessing road space is an important aspect of urban road network connectivity planning of the city. A graph or network is a set of nodes and edges, where the nodes are separate components of the network and the edges represent the connectivity between the nodes.

5.2.1ALPHA INDEX

The most useful and probably the best measure of network connectivity especially the most complex networks are the Alpha Index (Bamford C. G. and Robinson H., 1978). Cyclomatic number is one of the basic indicators of graph theory and is defined as the count of the number of basic circuits that exist in the graph. Alpha Index implements the concept of a circuit - a constraint, a closed path and an end to end on a single node (Dill, 2003). For the present study, the value of alpha index was classified in to three categories, with the highest connectivity is more than 0.20, moderate connectivity 0.15 -0.20, and less than 0.15 has been represented low connectivity in 2001 and 2011.

Table.1 Aurangabad City Road Network Connectivity- Alpha Index 2001-2011

Sr. No	Zones	2001			2011		
		Nodes	Edges	Alpha Index	Nodes	Edges	Alpha Index
1	Zone A	211	261	0.12	272	368	0.17
2	Zone B	136	198	0.23	186	298	0.3
3	Zone C	239	176	0.18	213	316	0.24

4	Zone D	207	312	0.25	249	387	0.28
5	Zone E	138	166	0.1	174	236	0.18
6	Zone F	126	153	0.11	158	209	0.16

Source: compiled by Researcher

The alpha index is used to calculate the network by the number of routes it takes from one point to another (Table.1). The highest Alpha Index score is in Zone B and D, which is about 0.23 and 0.25 respectively. It has been shown that the number of alternative roads between the vertices is very strong. The alpha indexes are taken as the moderate values ranging between 0.15 to 0.20 score. The moderate alpha index score found in only C zone i.e. 0.18. The alpha index has less than 0.15 properties as the low connectivity of the study area in 2001. The highest alpha index is in the total three zones i.e. B, C, and D which is 0.30, 0.24, and 0.28 respectively. It has been shown that the number of other paths between the vertices is the very strong road connectivity of the region. The moderate alpha index shows between 0.15 to 0.20 connectivity as per 2011.

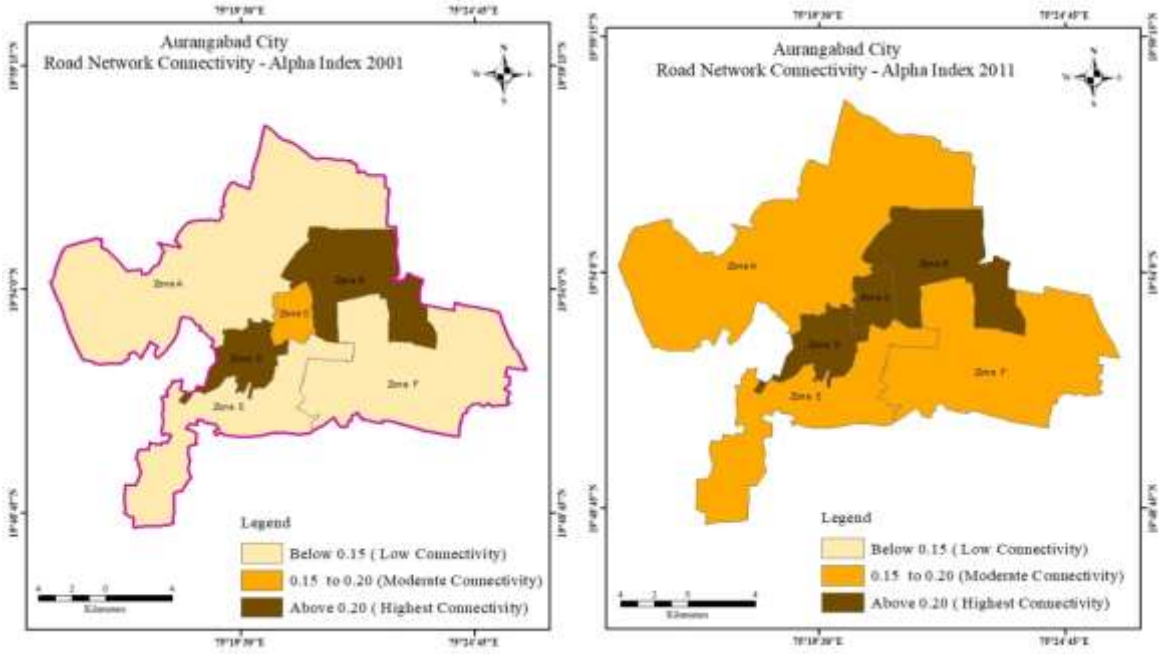


Figure.3 Comparative road network connectivity Alpha index 2001-11

5.2.2 BETA INDEX

The Beta Index shows a relation between the total number of edges to the number of nodes in the study region. The beta index range from the lowest values for the simplest network and high values to full network or well-connected ones. The simplest form of beta index is to measure road network connectivity. The higher the fixed number of links in the transportation network, the higher the number of possible routes in the network of the study region. Beta indexes are high in complex transportation networks (Rodrigue et al. 2006).

Table.2 Aurangabad City Road Network Connectivity- Beta Index 2001-2011

Sr. No	Zones	2001			2011		
		Nodes	Edges	Beta Index	Nodes	Edges	Beta Index
1	Zone A	211	261	1.23	272	368	1.35
2	Zone B	136	198	1.45	186	298	1.60
3	Zone C	176	239	1.35	213	316	1.48
4	Zone D	207	312	1.5	249	387	1.55
5	Zone E	138	166	1.2	174	236	1.36
6	Zone F	126	153	1.21	158	209	1.32

Source: compiled by Researcher

The beta index value of less than 1.25 is observed that the lowest values. It is absolutely absent during the period of 2011 in the study region (table.2). Moderately road network connectivity found in zone A (1.35), E (1.36), and F (1.32). For the reference period in the above fields, it is reported that the connectivity moderate connectivity is recorded as the number of nodes is less than the available paths in the region. The high beta index area is classified as an index value greater than 1.40. The highest beta index value has been recorded in zone B, D, and C which is 1.60, 1.55, and 1.48 respectively.

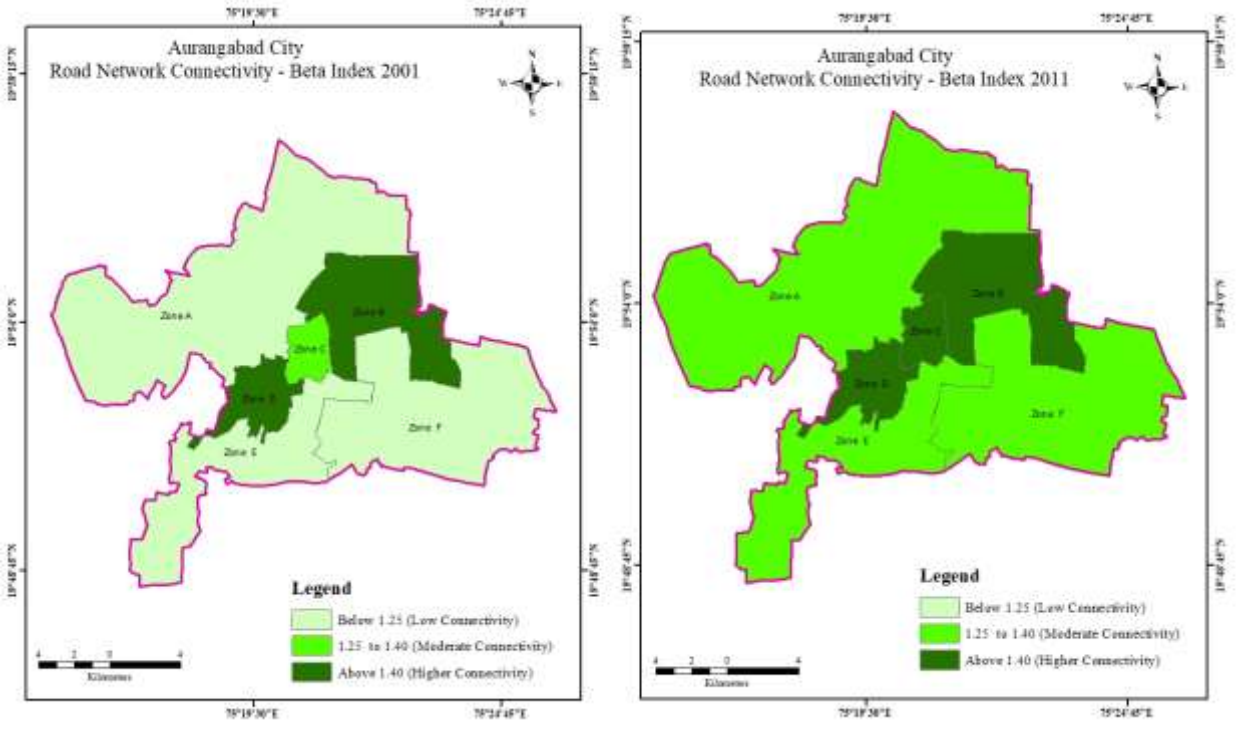


Figure.4 Comparative road network connectivity Beta index 2001-11

5.2.3 GAMMA INDEX

The Gamma index has been measured by the theoretical concentrated network connectivity of the region. The Gamma index is the actual ration of the number of edges with the maximum edge number in the road network. The connectivity of the network has been evaluated to the extent that it is connected to the maximum number connected with the edges on the network.

Table.3 Aurangabad City Road Network Connectivity- Gamma Index 2001-2011

Sr. No	Zones	2001			2011		
		Nodes	Edges	Gamma Index	Nodes	Edges	Gamma Index
1	Zone A	211	261	0.41	272	368	0.45
2	Zone B	136	198	0.49	186	298	0.53
3	Zone C	176	239	0.45	213	316	0.49
4	Zone D	207	312	0.5	249	387	0.52
5	Zone E	138	166	0.4	174	236	0.45
6	Zone F	126	153	0.41	158	209	0.44

Source: compiled by Researcher

The lowest gamma value in zone E shows lower network connections compared to the other zones (table.3). Moderate gamma index values between 0.40 and 0.45 during this period. Zone A (0.41), C (0.45), and F (0.41) represent the moderate value of the area with moderate road connectivity. It is observed that the total two zones have scored more than 0.45 gamma index i.e. is zones D (0.52) and B (0.53). it is showing that the denoted complete connectivity of these zones in 2001. As per the 2011 gamma index value between 0.40 to 0.45 indicate that moderate connectivity of the region. Moderate gamma index values indicate that zones A (0.45), E (0.45), and F (0.44). The region in which the gamma index value represents higher than 0.45 is considered as the highest connectivity area for the reference period. The highest gamma index values reported in zones B (0.53), C (0.49), and D zone which is 0.52. When beta values are 1 to 3, they represent a complex network of connectivity.

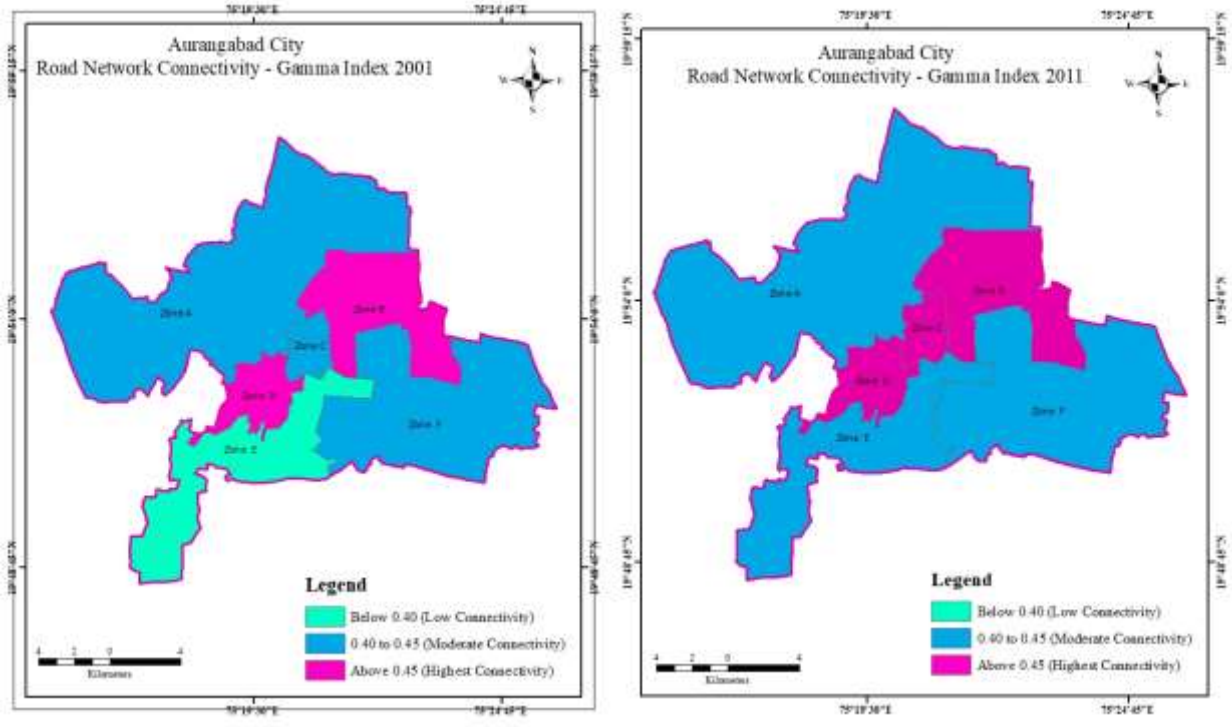


Figure.4 Comparative road network connectivity Gamma index 2001-11

6. CONCLUSION

In this study, taking the road network of Aurangabad city from 2001 and 2011 as an example, we analyzed the temporal and spatial patterns of the road network connectivity distribution of study area. It was revealed that the road network distribution is uneven throughout the city, and the focus is clearly on the center of the city, then gradually spreading to the perimeter from the center of the city. There is no doubt that the oldest area of the city has the highest road network density, which was distributed in zones B, C and D in 2011. Comparatively road network connectivity of the two periods, it is clear that the increasing rate of road development has definitely improved in the period 2001-2011. Analyzing the based on graph theory indicate that the applying of the alpha index to during 2001-2011 the range of road network connectivity reached the minimum score of the alpha index of 0.25 to 0.30 and the average of values range between 0.16 to 0.22. Explaining the beta index used for both periods of 2001-2011 the level of transportation connectivity of the minimum value range between 1.5 and 1.6, and the average value score from 1.32 to 1.45. The same is seen in the case of the gamma index. The average score of the gamma index has been increased from 0.50 in 2001 to 0.53 in 2011 where the average value also increased from 0.44 to 0.48 during this period. It has been revealed that there is an increases in road transportation connectivity to poor and complex connectivity.

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