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Research Article

Creation of Urban Road Networking System Using Geoinformatics

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ARTICLEINFO	ABSTRACT

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Introduction: The current road network arrangement in the majorityof India's big centers cannot accommodate the country's growing transport demand. In this situation, making better use of the current road network is necessary. The structural criteria, such as connection, accessibility, hierarchy, and morphology be examined and do needed assessment to provide the best use of the current road network.

Objectives: The purpose of this study was to assess the connectivity of Guntur City's road network in the Indian state of Andhra Pradesh.

Methods: The connectivity measurement is quantified by calculating the indices like alpha, beta, gamma index, eta, aggregate transportation score, andcyclomatic number, various locations in Guntur City were taken into consideration. To calculate the connection measures, one-kilometer radius buffer zones were generated from the centre of each location.This studyresults may serve as a reference for the city's planning of transportation authority as they assess the degree of connection at every place and develop more effective planning strategies to raise the city's overall connectedness.

Results: Urban transportation planning can make better decisions by utilizing Geographic Information Systems (GIS).

Conclusions: Additionally, the current study attempted to demonstrate the effectiveness of GIS in analyzing the transport network structure's connectivity-based performance in the research area.

Keywords: GIS, Road Connectivity, Analysis and Planning, Networking, Urban Transportation.

INTRODUCTION

Within the urban framework, the transportation system plays a critical role in a location's economic development. The way a transport structure functions is a good indicator of how well an engineer adheres to that location. A well-functioning transportation system is essential to the ongoing development of a region. These days, specialized integrated systems like Geographic Information Systems (GIS) are available to improve the functionality and caliber of the transportation infrastructure.Any road network must have these four fundamental components: hierarchy, morphology, accessibility, and connectedness. A well-connected street system makes it easier to go to your intended locations. An ordered, hierarchical road system facilitates varying vehicle volumes, speeds, and types of transportation (Litman, 2005).To assess the degree of organization and interconnectivity of the street structure, a connectivity indicator is unquestionably required. The ratio of a structure's vertices to edges makes this easy to measure (Ewing, 1996). A acceptable level of road interconnection is indicated by higher connectivity indicator values (Litman, 2005).For many firms, the network connectivity indices will serve as a foundation for accessibility and efficiency of the road network, which is useful when making mobility planning decisions (Handy, et al., 2002). Finding the best solutions for identifying emergency utilities in Varnasi can be aided by network analysis (Kumar and Kumar, 2016). Arc GIS software was used to quantify transport network indicators, and the results showed that there

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were few road links in Kerala's Karsagodtaluk(Vinod, et al., 2003). Using south west Delhi as an example, the use of the Arc GIS network analysis tool is described as being available for solving numerous network issues related to transit structural performance (Arora and Pandey, 2011) Using several connection indices, transport structural performance based on connectivity is calculated, and the results show that Aurangabad has adequate network infrastructure (Nagne, et al., 2013). The Arc GIS network analysis tool was utilized by the city of Dehradun to find answers to numerous issues with the transportation system (Nijagunappa, et al., 2007). Kansky (1963) presented three key metrics, namely Alpha, Beta, and Gamma, to measure connectedness. These metrics make it simple to understand how well the transportation structure performs in relation to road connectivity (Kansky, 1963). Trans-Amadi, Port Harcourt, Nigeria's road-network system was evaluated using the Beta index, road density, connectivity, road kinds, and condition (Obafemi, et al., 2011). With the use of network indices based on graph theory, the inter-relation of inter connection and changes in land cover was examined for the Thai province of Lop Buri (Patarasuk, 2012). In order to help the rural roadplanners, decisionmakers, researchers, and other various level administration people, an attempt was made to establish a GIS-database with rural roads. The database was created using the network's structural analysis, which included shortest path analysis, Average Pavement Condition Index (APCI) values for each road edges, and connectivity analysis (Manyazewal, et al., 2014).

DATA USED AND DESCRIPTION OF STUDY AREA

The study area of this paper was selected 11 locations of Guntur mandal, Andhra Pradesh, India. These locations are selected randomly covering the all directions inGuntur mandal. Guntur City is the district headquarters, Guntur Mandal is well connected by rail and road transport. The road network vector file of Guntur city was downloaded from the Open Street Map and updated the roads use of Google maps in QGIS. The locations selected for this study are Balaji Nagar, CPI Colony, Gandhi Nagar, Gorantla, Gujjanagundla, Jonnalagadda, Nagarampalem, Naidupet, Nallapadu, Nehru Nagar and RTO/RTA Guntur. Buffer zones of a kilometre radius were drawn for each location. The research study area map is shown in **Figure 1.Figure2** shows the selected buffer zones at locations for study the connectivity analysis.

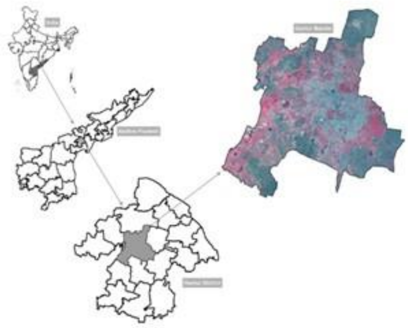

Figure 1. Study area - Map Illustrating Study Area Location

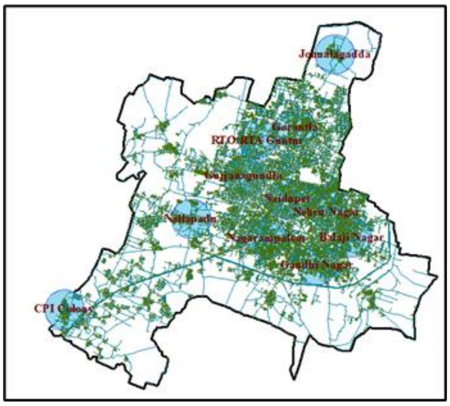

Figure 2. Buffer zones of locations for connectivity analysis

OBJECTIVES

The primary focus of this research is to assess how effective the road system is in Guntur Mandal, located in the state of Andhra Pradesh, India, with regards to its structural connectivity. The specific goals include:

To compute multiple network-connectivity metrics within a onekilometre radius for each location.

To use the Aggregate Transportation Score to assess each location's degree of road network connectivity.

To designate areas with networks that are poorly, somewhat, and highly connected.

METHODS

Methodology for evaluating urban road network connectivity using geoinformatics, with a focus on Guntur, Andhra Pradesh (AP). This methodology involves utilizing GIS tools to assess and quantify the road network connectivity of the urban involves following steps. Import road map into GIS software and identify the location to study the connectivity. Create the buffer zone radius of 1 Km to determine the connectivity level at each location depends on ATS and compute the indices. Prepare the layers for link and nodes to calculate the road network connectivity. This methodology helps to comprehensively evaluate urban road network connectivity, providing insights into how well different areas are connected, and offering actionable recommendations to improve urban mobility and accessibility in Guntur, AP. The nodes and links count for Jonnalagadda and Nallapadau within a 1-kilometer buffer, calculated using Arc GIS 10.5 network analysis tool are shown in **Figures 3(i) and 3(ii).** In the same way, the vertex (are known as nodes) and edges (are known as links) of all other sites were determined and measured using GIS software (Arc GIS 10.5). Connectivity metrics such as the total number of vertices, total number of edges, α index (alpha), β index (beta), ¥ index (gamma), ŋ index (eta), μ number (cyclomatic Number - CN), and cumulative transport score are used to analyze the city road network's connectivity. The connectivity measures used in this study can be found in **Table 1**

Table 1. Different connectivity indices with equations

S. No	Index	Equation & Notation	Description	Defines Connectivity
1	α index (alpha)	α=(e-V+1)/2v-5	e = number of edges / links v= number of nodes / vertices	Explains about circuitry of the network. Higher value indicates more connectivity.
2	β index (beta)	β = e/v	e = number of edges / links v= number of nodes / vertices	Explains the complexity of the network. A higher value indicates more connectivity.
3	¥ index (gamma)	¥ = e/3(v-2)	e = number of edges / links v= number of nodes / vertices	Explains about the completeness of the network. Higher value indicates more connectivity.
4	ŋ index (eta)	ŋ = L/e	L= summation of all the edges e = number of edges/ links	Explains the utility of the given network. A higher value indicates more connectivity.
5	μ number (cyclomatic Number - CN)	μ = e-v+1	e = number of edges/ links v= number of nodes/ vertices	Explains about the closeness of graphs in the network. Higher value indicates more connectivity.
6	Total Transport Index (TTI)	TTI = β+α+¥+μ	α = alpha index β = beta index γ = gamma index μ = Cyclomatic number	Higher value indicates more connectivity and efficiency.

Source: Sahitya, K.s. and Prasad, C,S,R,K., 2020. Methodology for city level urban road network connectivity analysis using geographical information system (GIS). Stavebni Obzor-Civil Engineering Journal, 29(1).

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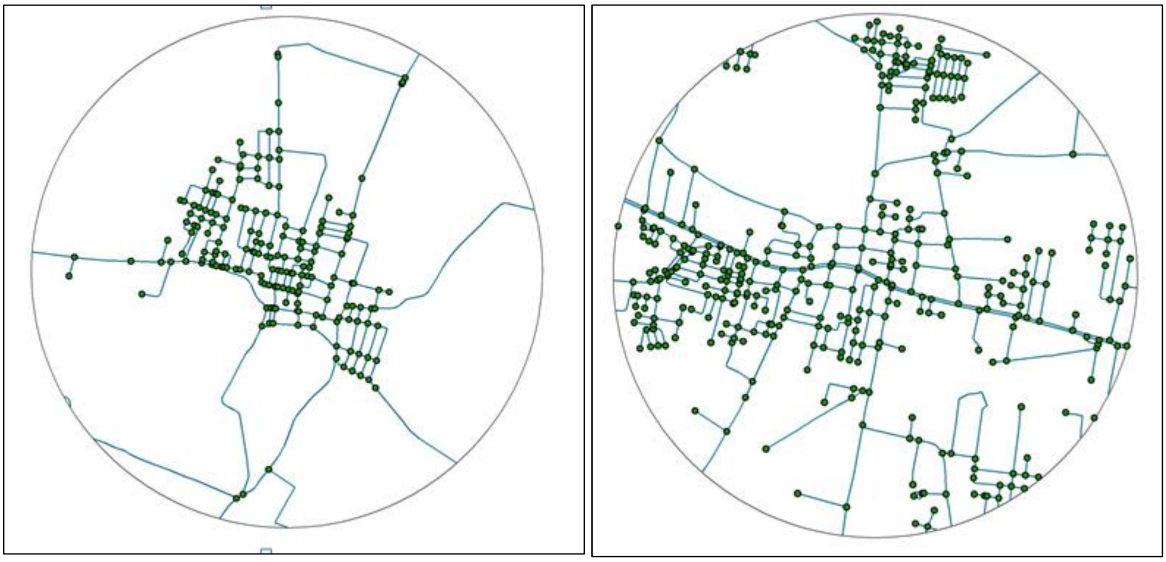

Figure 3(i) & (ii) Vertices and edges of Jonnalagadda andNallapadau

RESULTS

The all described connectivity indices were calculated for 11 locations within the 1 km radius buffer zone and the results are presented in **Table 2.**

Table 2. Statistics of network-connectivity indices

S.NO.	Location	Vertices	Edges	α index	β index	¥ index	ŋ index	µ number	TTI
1	Balaji Nagar	875	1681	0.46	1.92	0.64	0.24	807	810.03
2	CPI Colony	266	477	0.40	1.79	0.60	0.22	212	214.80
3	Gandhi Nagar	908	1703	0.44	1.88	0.63	0.23	796	798.94
4	Gorantla	805	1406	0.38	1.75	0.58	0.21	602	604.71
5	Gujjanagundla	847	1605	0.45	1.89	0.63	0.24	759	761.98
6	Jonnalagadda	182	353	0.48	1.94	0.65	0.25	172	175.07
7	Nagarampalem	947	1807	0.46	1.91	0.64	0.24	861	864.00
8	Naidupet	850	1650	0.47	1.94	0.65	0.24	801	804.06
9	Nallapadu	381	657	0.37	1.72	0.58	0.21	277	279.67
10	Nehru Nagar	1099	2156	0.48	1.96	0.66	0.46	1058	1061.10
11	RTO/RTA Guntur	783	1684	0.58	2.15	0.72	0.27	902	905.45

The alpha index indicates the proportion of the most desirable chains in the network, the α index (alpha) values ranges betweenzero to one, where zerospecifies theleast connectivity and onespecifies thehighestnetwork connectivity. Theα index (alpha) value for the eleven locations ranges between from 0.37 to 0.98. The average α index

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value of 0.5 indicates a Moderate level of circuitry in the road-network of the location. β index (beta) values most of the timelays betweenzero to one, with zero indicating leastnetwork connectivity and one indicating highestnetwork connectivity. Beta index values greater than 1 indicate more complex network connectivity. All locations have beta index values shown higher than 1, which indicates the compound nature of the city's road network. The value of the 1.8 beta index (the average β index (beta)) is a good goal for planning.

Since ¥indexis generally represented as a connection rate, the average Gama index, which is 0.63, shows that the network is connected to 63%. The higher the µ number (cyclomatic - CN) and total transport index (TTI) values show the high network-connectivity and high efficiency of connectivity.

AGGREGATE TRANSPORTATION SCORE (ATS) OF SELECTED LOCATIONS

The connectivity of a area or a location was evaluated by the Total Transport Index (TTI). TTI is able to understand the overall connectivity of region. The TTI is calculated by adding of α, β, ¥, ŋ, and µ number. Therefore, TTI can interpret from global connections to regions or places. The higher the TTI indicate the great degree of connectivity and efficiency of transportation of that particular region of location. This workattempted to classify and evaluate the 11 sites selected for analysis of road network connectivity depends on the obtained TTI values. Road networks in various places are classified into least connected networks, moderately and well connected networks. The connection levels are according to the TTI value is classified in **Table 3.**

Table 3. Level of network connectivity based on overall TTI

S. No	Total Transport Index Value	Connectivity Level
1	0-200	Less network connected
2	200-300	Moderately network connected
3	>300	Well network connected

The sites selected for road network-connectivity analysis are classified usingTTI values, and presented in **Table 4**.

Table 4. Classification of network-connectivity of various places

Sno	Location	TTI	Connectivity Level
1	Balaji Nagar	810.03	Well network connected
2	CPI Colony	214.80	Moderately network connected
3	Gandhi Nagar	798.94	Well network connected
4	Gorantla	604.71	Well network connected
5	Gujjanagundla	761.98	Well network connected
6	Jonnalagadda	175.07	Less network connected
7	Nagarampalem	864.00	Well network connected
8	Naidupet	804.06	Well network connected
9	Nallapadu	279.67	Moderately network connected
10	Nehru Nagar	1061.10	Well network connected
11	RTO/RTA Guntur	905.45	Well network connected

The results presented in **Table 4** show the location Jonnalagadda is less connected network, CPI Colony and Nallapadu are moderately connected network. Remaining locations Balaji Nagar, , Gandhi Nagar, Gorantla, Gujjanagundla, Nagarampalem, Naidupet, Nehru Nagar and RTO/RTA Guntur have shown a well-connected network. The urban transportation planners may concentrate more on the less connected network and moderately connected locations to develop the network connectivity of the Guntur mandal and maintain the well-connected network areas as per the demand which increases the road network connectivity of the city.

DISCUSSION

The road network connectivity of Guntur mandal is evaluated and analyzed using the structural parameters, connectivity is one of the key parameter in these studies. The partial analysis of the network study is shown in this study which plays a key role in identification of transportation problem in Guntur city using the Geographical Information System (GIS). This study is mainly focused on the evolution of structural road network-connectivity. This attempt is analyze the connectivity of selected locations, with 1 kilometer buffer radius at each location in the Guntur mandal. Based on the graph theory network indices with help of vertices and edges are used in to evaluate the network indices which describe the road network connectivity. The Total Transport Index was calculated for the different location buffer zones and evaluate the road network connectivity. The three level was classified based on the TTI score and categorized as less.

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