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Spatial Analysis of Roads Network in Ramadi City

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ABSTRACT

One of the most important aspects of developing any area is creating a viable road network and defining the relationship between landscape use and road networks. Proper communication and direction are essential to the proper construction of any network. However, Ramadi's road network has not received much attention and evaluation. As a result, the purpose of this research was to evaluate the connectivity of the road network in the city of Ramadi according to the results of the indicators that were used: the alpha index, beta index, gamma index, and eta index. According to the results shown by the connectivity indexes, the network suffers from poor connectivity. Finally, the network needs to be improved by adding new links.

1. Introduction

The city of Ramadi is considered the center of Anbar Governorate, as it is witnessing continuous change and expansion in all dimensions. As a result of rapid economic and social change, there is inevitably high traffic for goods and passengers, which has led to a high demand for transportation. This demand requires an equivalent and efficient delivery of network system infrastructure, modes, and services (Bogale, 2012). Regardless of the fact that the road infrastructure is the first element in the formation of the transport system (McCabe, 2003) and that the area covered by the road network is an indicator of the degree of mobility of people, goods, and services within an area, and the quality of the network measures the ease and cost of this mobility (Ogunleye, 2011), we find that the road network The roads in the city of Ramadi suffer from insufficient infrastructure in terms of availability (the absence of many important links from its structure) (Bogale, 2012), and the lack of many network links, followed by the shortest paths, especially those that represent a direct link between two neighboring cities or even two paths to connect, limits the level of movement of people and goods within a specific path through the available links (Bogale, 2012). Not recognizing that the development of mobility favors long trips by private car These disruptions to the transportation system will lead to significant economic and social pressures, including

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hampering people's ability to get to work on time, affecting business through delayed delivery and supplies, and increasing freight costs, delay or cancellation of industry, meetings, etc. (Gil, 2014; Jenelius, 2009).

The urban transportation system is a traditional transportation network that has piqued the interest of several research studies (Bando et al., 1995; Wang et al., 2012).

Among the transportation network methodologies, the most beneficial is connectivity assessment. It has various indices, each with its own meaning. (Alpha, Beta, and Gamma) indexes measure the most basic components of a transport system (Rodrigue et al., 2013). To obtain the connectivity index, the network (line) and intersection (node) are required. These indicators can be used to detect changes in network structure in system and traffic assessments. (Levinson, 2012; Lee, 2005). The alpha index measures the ratio of a network's exact number of interconnects to its highest allowable number of interconnects. Beta index is used to determine the degree of road connectivity, and gamma index is a measure of the number of links in a network as a ratio (Obafemi et al., 2011). To analyze the network's connectivity, a spatial assessment of Erbil, Iraq's constructed road network, was completed. Furthermore, the research concentrated on detour analysis. Because of the steepness of the terrain, the results indicated poor connectivity (Khazaal, 2009).

(Taran & Makhamra, 2015) used GIS to conduct a spatial evaluation of a rural transport system in Jordan's Al Mafraq city to assess connectivity. According to the Gamma index, the percentage of connection was 42% in the study. In contrast, the circuit has a fairly low alpha index of 11%.

To achieve the goals of this research, we must undertake an analysis of the road network. Graph theory underpins methods for evaluating transportation networks. The goal of graph theory will be to represent the structure of the network rather than its appearance. It is focused on the writing code of networks related to mathematics and the measurement of their attributes. Networks, nodes, and linkages are all visual representations of information. A network usually consists of a group of nodes and links. Connectors refer to the lines connecting the two vertices, while nodes represent the number of contacts. In the transmission network, there are many methods of analysis, each with its own methodology (Obafemi et al., 2011; Ducruet & Rodrigue, 2013).

2. Method

The research relied on an analytical approach using the geographic information systems program to find the characteristics that affect the road network. The road network of the study area (Al-Ramadi city) is represented as a graph consisting of points and lines, where the points refer to the nodes and the lines represent the network links. To facilitate the description and analysis of the network, its connectivity was measured using the alpha, beta, gamma, and eta indices (see Figure 1). The grid lengths were measured based on ArcGIS 10.8 (see Figure 2).

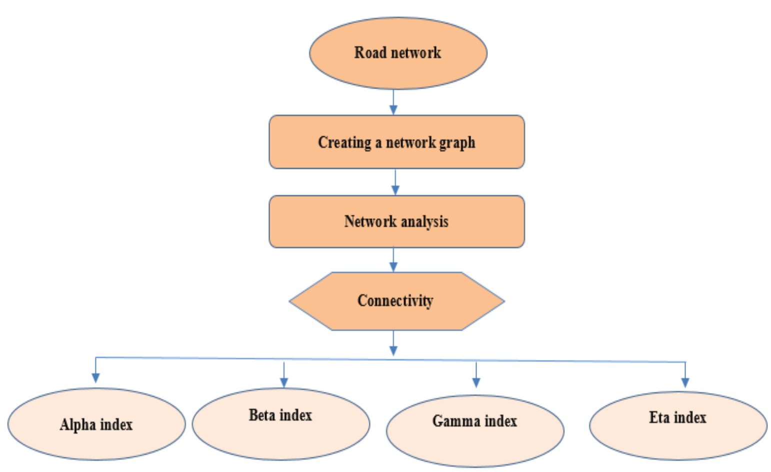

Fig. 1 Research methodology chart

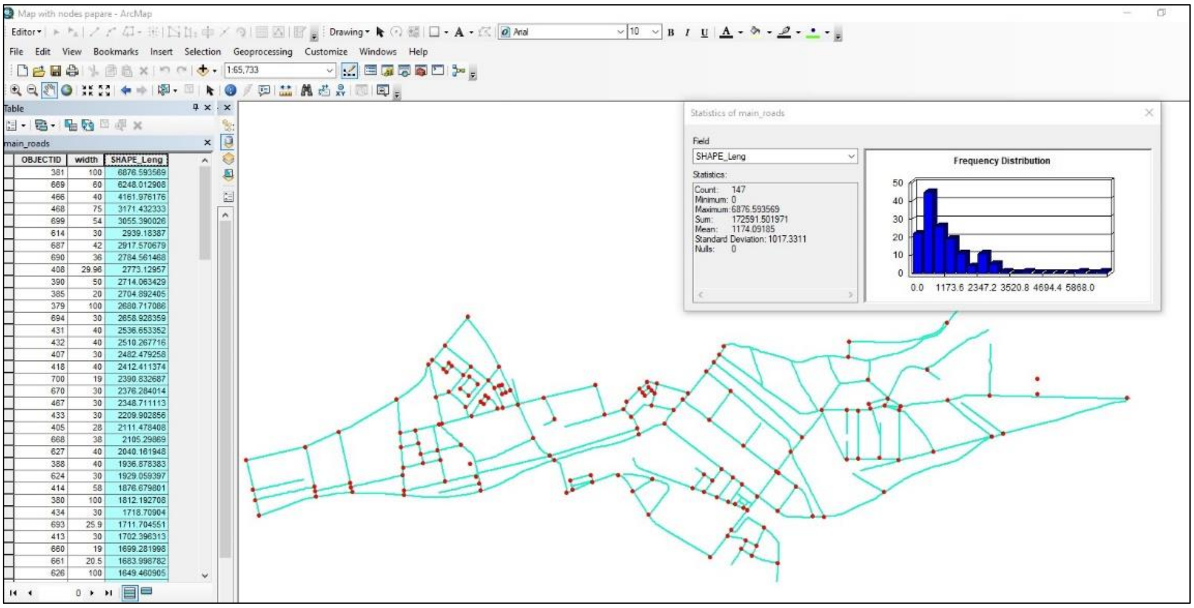

Fig. 2 A program ArcGIS10.8 interface when applying to calculate the lengths of the Ramadi city road network

To convert a real network into a flat graph, two important points must be followed:

- First point: every endpoint and intersecting spot is a node.
- Second point: each connecting node is connected by a drawn line.

By graphically depicting the network, analysis is enabled. The network and access were studied using a graphical depiction of the road network. For connection and coverage analysis, the following indices are used: Alpha index (α), Beta index (β), Gamma index (γ), and Eta index (η). According to Buyong (2007), Table 1 shows the equations and interpretations for calculating the following indicators:

Table 1 – Indexes used in connectivity analysis.

No.	Index name	Equations	Eq. number	Description
1	Alpha	$\alpha = \dfrac{e - v + p}{2v - 5}$	(1)	This indicator measures network connectivity by comparing the number of cycles in the graph with the maximum number of cycles. Network connectivity increases with an increase in the alpha value. The value of this indicator ranges from 0 to 1, where the value of 1 shows high correlation, which is very rare, while the value of 0 is owned by networks and simple quarrels.
2	Beta	$\beta = \dfrac{e}{v}$	(2)	The beta indicator is used to measure the extent of connectivity in a network, as it can be represented by the relationship between the number of links and nodes in the graph. When the network is connected in one turn, the value of the indicator is equal to 1, while this value increases with the increase in the number of nodes and paths, and this is what happens in more complex networks.
3	Gamma	$\gamma = \dfrac{e}{3(v - 2)}$	(3)	A measurement of connectivity that is taken into account is the connection between the number of seen and anticipated links. Gamma has a value between 0 and 1, with 1 indicating a perfectly connected network, which is extremely uncommon.
4	Eta	$\eta = \dfrac{L}{e}$	(4)	Average link length. Adding new nodes reduces Eta because the length of each link is decreasing. The eta values of complex networks are low.

where:

e: The number linked connections

v: The number of nodes in the network.

p: The number of non-connected sub-graphs in the grid.

L: The total network length.

3. Results and discussion

The road network of the city of Ramadi was chosen as a case study in this research, with a total length of 172 km (see Fig. 3). The number of linkages and the network's nodes is shown in Fig. 3 with 211 links and 167 nodes.

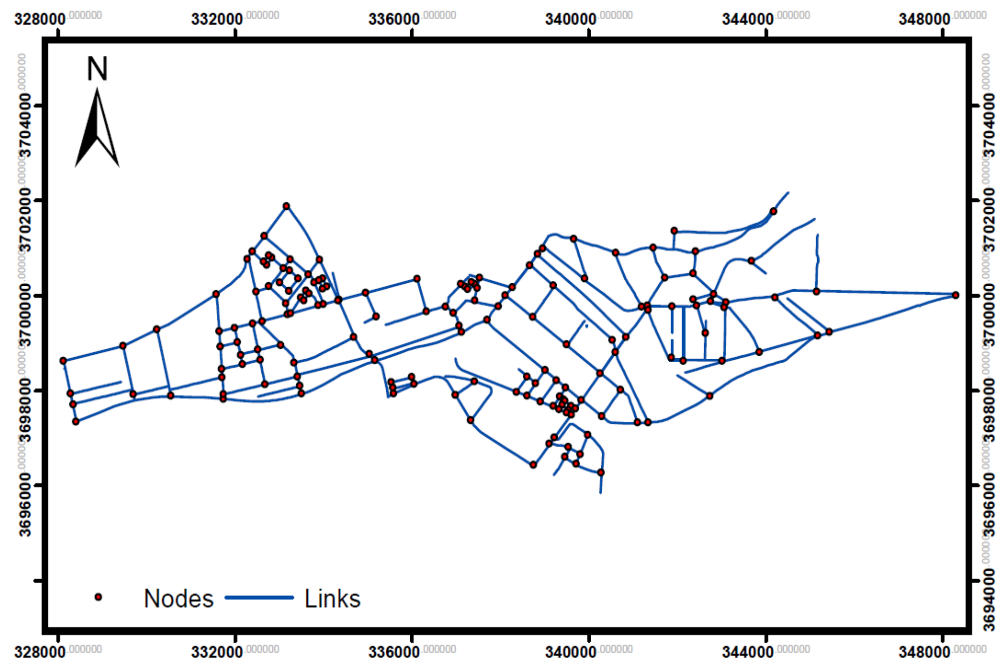

Fig. 3 Nodes and links of Ramadi Road network using ArcGIS10.8 software

According to the number of links and nodes that were obtained based on the network diagram (Fig. 3) and by applying the equations in Table 1, each of the indexes is found to evaluate the connectivity of the network. Table 2 shows the results of applying the equations.

Alpha index = (211-167+21) / (2*167-5) = 0.197

The alpha value indicates that the network connection is weak, as it requires (264) connections to reach its maximum level. Thus, in order to fully cover the neighborhoods of Ramadi, new lines connecting the suburbs must be constructed.

Beta index = (211/167)
= 1.26

The road network was moderately complex, according to the beta index, since the index was slightly above one and the length of the links was short.

Gamma index = (153/3) (132-2)
= 0.43

According to the gamma index value, this indicates that the network link on this scale is at a low level; for the network link to be optimal, there must be (237) new connections between the current nodes in the city in order to reach the network's full degree.

Eta index = (172/211)
= 0.82 km/link

According to this indicator, the degree of spread of the network is 0.82 km/link, which indicates that the street network in Al-Ramadi city is well-spread; this indicates that the lengths of connections in the city are short, which provides a clear picture of the convergence between residential communities and the closeness of the distances between them.

Table 2 – Results of indexes used to evaluate connectivity of Ramadi network.

No.	Index name	Index value	Explanation
1	Alpha	0.197	The connectivity of network is low.
2	Beta	1.26	The network was moderately complex.
3	Gamma	0.43	The Ramadi network has low level connectivity.
4	Eta	0.82	The average node separation is modest.

4. Conclusions

The key findings of this research can be explained as follows:

1. According to indexes (alpha, beta, gamma, and eta), the connectivity of Al-Ramadi road network is weak. The values of indexes were 0.197, 1.26, 0.43, and 0.82, respectively.
2. Through the results of the research, the study area suffers from a decline in network connectivity, so priority must be given to constructing new roads as well as developing a plan for the city to avoid the shortage in the network, which in turn will help increase its connectivity. This is achieved by increasing the number of connections between the city's neighborhoods.

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