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Quantitative Analysis of Urban Road Network of Dammam Metropolis

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Abstract

Urban Road network is considered one of the most important infrastructures that was given a lot of attention Saudi Arabia. The research attempted to examine the urban road networks in Dammam Metropolis, through analysing the infrastructure of the urban road networks in Dammam city to state how easy the access and the communication between the transport contracts and how relative they are as well as to achieve the desired objectives of evaluating the efficiency of roads networks. Moreover, the study employed the technology of Geographical Information Systems (GIS) in processing and analysing the data of the urban road networks in Dammam city, especially the tool of Network Analysis to analyse and determine the degree of interdependence by applying several quantitative indicators, In the light of the quantitative analysis of the urban road networks and via statistical strategies, it is worth noting that the deviation factor of urban roads reached (113%), meaning the length of roads under the scope of the study do not deviate from straight lines to a large extent.

Keywords: dammam metropolis; network analysis; quantitative؛ road; transport.

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1. Introduction

The road network is also one of the most important components of the transportation system, as it represents the vital arteries that enable all sectors of the city to carry out their functions. It reflects the shape and morphological identity of the city; playing an important role in reducing distances and ensuring ease of movement of individuals from one place to another, which in turn contributes to achieving the demands of economic development, social convergence and cultural exchange. Therefore, upgrading the road network is one of the criteria or indicators pointing to the level of urban development. As the progress of countries is measured by the extent of the progress of the means and transportation systems in them, according to the complementary relationship between it and all other development sectors [6].

The city of Dammam, one of the urban centers in the Kingdom, is witnessing an accelerating urban expansion. This is in response to the geographical location that represents a link between the Kingdom and neighboring Gulf countries as well as the economic weight it enjoys. One that had a clear impact on the acceleration of urban growth reflected negatively on the urban road network, as it was no longer able to absorb the increase in traffic volume. Taking this into consideration, the study of the urban road network in the Dammam metropolitan area is the objective to determine the efficiency of the network.

2. Aims and Significance

The study is determined by the reliance on the quantitative analysis of the network in the city of Dammam that reflects many of characteristics of economic and social repercussions. The significance lies in the following points:

A. The area under study did not have enough studies in the geography of transportation that are commensurate with the size and position of the region and its economic weight in the Kingdom.
B. The study's contribution to modifying and adding to the studies and literature that dealt with the road network in the Eastern Province in general.
C. The lack of studies in the Kingdom on road networks and urban streets and their quantitative analysis despite the urgent need for such studies.
D. Providing a geographical database that can be updated and modified when needed, in addition to producing a set of maps that will be of help to planners and decision-makers.

3. Issue of Selected Study

Dammam is an urban center that is highly attractive to the population. Providing many job opportunities; due to the wide variety of economic activities and their spatial differences, which contributed during the development era to directing the polarization towards the urban center. An intensity of development that resulted in the confluence of the three urban centers (Dammam-Khobar-Dhahran). For that, Dammam expanded with important government departments as well as the accumulation of the high proportion of the workforce. The three-centers are then linked by a network of urban roads that are not at the same pace in their efficiency. Through its spatial variation and differences of efficiency, the network has become unable to meet the requirements of the transport

movement in the metropolis of Dammam, struggling to keep pace with the growth and expansion of society and the steady population increase. As of 2014, the population of Dammam metropolis reached (1608958)[1] people that is considered the main reason for the increase in the number of vehicles, which numbered (44,1305)[2], leading to a high density of traffic and congestion in the metropolis. Therefore, the problem of traffic jams rises dramatically during the morning and evening peak hours, making business trips increase flight times, and parking and waiting times. All of the aforementioned elements led to high rates of environmental pollution.

4. Questions

A. What are the economic indicators of the urban road network in Dammam metropolis?
B. How efficient is the urban road network in Dammam metropolitan area?
C. What are the indicators of network structure analysis and the degree of interconnection in Dammam metropolis?

5. Objectives

A. Defining the characteristics of the urban road network in Dammam metropolis, its classification and geographical distribution.
B. Analysis of the economic indicators of roads and analyzing the structure of the urban road network using quantitative methods to identify strengths, support, weaknesses to address them.
C. Identifying the ease of access and communication between the transport nodes in the network and determining the degree of interconnection between them.

6. Literature Review

It is worth noting some of the studies that relate to the subject of transportation, and the selected area, for example, but not limited to.

A. "Route Network Analysis in Khartoum City " by Elsheikh and his colleagues (2016)

This study entitled aimed to provide digital maps of road paths by building a geographical database to analyze networks and identify the closest routes based on the time of arrival of population service sites.

B. "Urban Road network analysis of Yenagoa, Bayelsa State Use" by Idhoko and his colleagues (2016)

This study is based on building a geographical database of GIS network analysis to answer questions about how to access locations and spatial research to find the shortest routes between locations according to time and distance for emergency response services in order to improve quality of life.

C. "Analysis of Urban Road Traffic Network Based on Complex Network" by Zhao Tian and his

1 - Source [7].
2 - Source [8].

colleagues (2016)

The study aimed to analyze the topology structure of road traffic representation, highlighting the functional characteristics of the urban network and analyzing the statistical characteristics of the road traffic network according to the three network models.

D. "Analysis of the characteristics of the road network in Hebron using GIS" by Juicy and Burgan (2018)

The study is rooted on the analysis of the characteristics of the road network using GIS to diagnose the reality of the network and to study the natural and human factors affecting the roads highlighting the problems that stand in the road network, The study found the percentage of road area relative to the area of the city reached (9.73%), as well as showed That The turning indicator of the road connecting the city center and wadi al-Qadi area reached 338%. Therefore, it recommended the establishment of more road connections to connect to link and integrate the road network.

"Urban Road Network in Mecca, using GIS," by Talib (2018)

This study aims to highlight the role of GIS technology in the analysis of road network, particularly spatial analysis of network paths, to highlight the spatial relationship of the geographical distribution of the network and geographical distribution areas of the population and to apply quantitative methods to extract the spatial relationships of the road network in Mecca. As it found that the road network in Mecca is modern and developed, to increase the length of roads, which reached 5926.4 km, especially paved ones.

By reviewing previous literature, it is noted that most of these that deal with transportation geography have common denominators, seeking actively to adopt a similar framework of analysis of transportation networks. However, the difference in the current study lies in the geographical contribution to representing the reality of the urban road network and streets in urban agglomerations.

7. Method

To achieve the objectives of the study, the research applies the quantitative descriptive approach to analyze the reality of the urban road network to identify and classify the general characteristics of road networks, and their traffic movement, in order to determine the extent of the network's interrelationship by revealing the spatial relationships between different phenomena.

8. Data Sources and Collection

- **Primary sources:** These are references on the geography of transportation as well as theses, periodicals and research related to the subject of study.
- **Statistical sources:** Majority of these statistics provided by the Ministry of Transport in the Eastern Province, the General Authority for Statistics in the city of Dammam, the General Administration of

Roads in the region, the General Administration of Traffic in the Region, and the Department of Studies and Designs in Dammam. All of these statistical sources come at the forefront making the spring from which the study draws its data.

- **Maps and satellite visuals:** The study relies on base map of the metropolis of Dammam, based on an unpublished digital map of the Eastern Province Municipality, the General Department of Urban Planning in Dammam for the year (2014). As the administrative boundaries of the metropolis of Dammam were determined according to the map of the Ministry of Municipal and Rural Affairs. As well as employing images and maps from Google Earth to determine the urban planning patterns of Dammam metropolis, to address the identification of road network paths, and to match the area under study contract to the urban road network.

9. Area of Study

The city of Dammam is located on the coast of the Arabian Gulf in the eastern region of the Kingdom of Saudi Arabia, (figure no 1), and it is bordered in the north by the Arabian Gulf along with Qatif, Jubail and Ras Tanura governorates. It also shares its borders in the east and south with Abqaiq governorate. It extends astronomically between latitudes (03° 26° and 30°26°) north, and longitudes (45°49° and 15°50°) east.

The Dammam metropolis includes three cities, namely Dammam, Al Khobar, Dhahran, the cities of Dammam, Dhahran, Khobar are of the most important urban centers in the Kingdom, and are linked to each other by a network of urban roads that, of course, vary in length, width, capacity, relative importance and function as well as differ in the volume of daily traffic and their current level of service. Available data indicates that the total lengths of the urban network of metropolitan Dammam, according to the year 2014, are about (8334.37) kilometers.

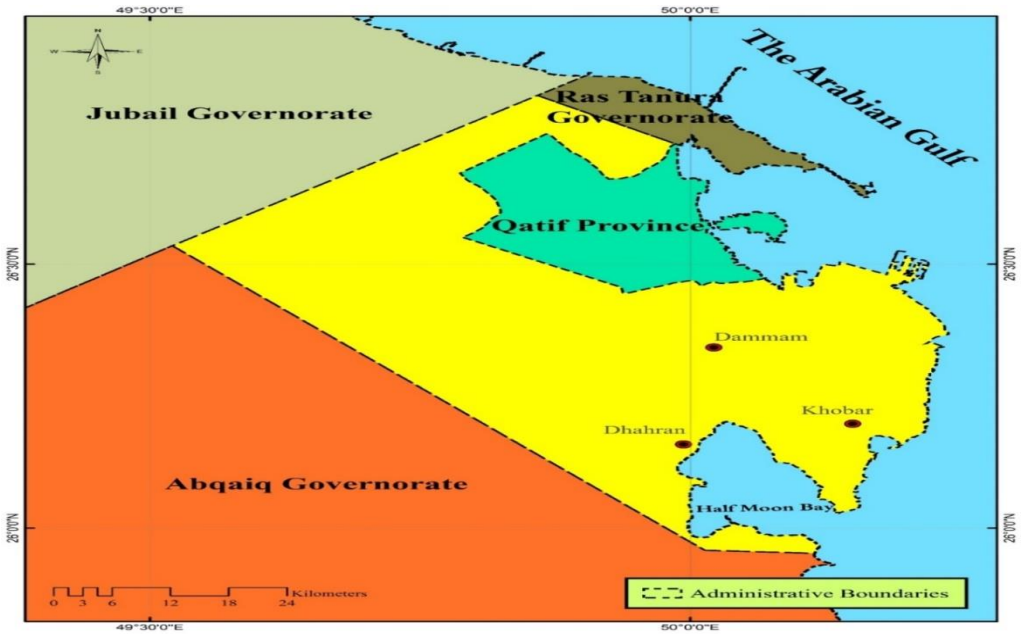


Figure 1: Administrative Boundaries of the Area under Study in 2014

10. Exposition and Analysis

I. Introduction to the quantitative analysis of the road network

The theory of networks is of great importance, as it enables to determine the maximum distances in the transmission network, or the least time and the lowest cost, and we can distinguish between three forms of the infrastructure of networks, which are paths, trees, and circuits, [3].

The urban road network in the metropolis of Dammam, Kingdom of Saudi Arabia, the scope under study, is considered of Flat networks with only two dimensions.

Peter Davis has identified three types of flat networks based on the interconnectedness of the network through the presence of connections between nodes, and they can be identified as follows:

1. Fragmented network: the links between some of its nodes are interconnected, while others are non-existent.
2. Interconnected network: all its nodes are connected by direct or indirect links.
3. The complete network: It is characterized by that each node is interconnected with the rest of the nodes in the network with direct connections [1].

By classifying the previous patterns on the network of the selected area, the urban road network of Dammam metropolis can be classified as an interconnected network if it is taken into account that only the nodes are the places of transportation attraction for urban residents.

II. The economic indicators of roads in the city of Dammam

There are many economic indicators that have been applied to analyze urban road networks in the city of Dammam, illustrated as follows:

Detour Index, Route Factor

By applying the inflection index of the urban roads of Dammam metropolis, whose lengths are (8334.37) km in 2013, with (95) links to urban roads in the network, it is clear that the total real lengths of roads in Dammam metropolis deviate from straight lines by (13%), where it is recorded. The inflection index of the studied area (113%) reveals the low rate of deviations of urban roads in Dammam metropolitan area, like other mountainous regions of the Kingdom, as a result of the plain nature in the cities of Dammam metropolitan, which enables the roads to extend straight. For that it is possible through the data of Table No. (1) to divide the urban roads, according to the inflection indicator, into three categories, listed as follows:

1. Ways with perfect integrity up to (100%):

It records (27) of the roads of the studied area in the urban road network with complete integrity, where its lengths are straightened at a full rate of (100%), achieving the maximum efficiency of roads and streets

in the metropolis of Dammam. As the straightness of urban roads is represented in many streets in the metropolitan cities. As in the analyzed area, it points out the flatness of its surface, its absence of natural obstacles that may obstruct road paths, which gives a great advantage in the extension of urban road paths in Dammam metropolis without negative deviations, such as Omar Ibn Al-Khattab Road and the First Street.

2. Roads in which the deflection coefficient ranges from (101%) to (150%):

It is represented in most urban roads and streets constituting the bulk of the reality of (95) links of the studied urban roads and streets. As their lengths deviate from straight lines in urban centers by between (1%) to less than (50%), and these roads are located in Dammam making up the links of the analyzed area, as shown in Table No. (1).

3. Roads in which the inflection coefficient ranges from (151) and above:

When extrapolating the data from the table below, it becomes clear that only three of the roads in the area under study have a deflection coefficient of more than (151%) and above. Dammam metropolis, as well as the Corniche Road link, in which the negative deviation coefficient reached (152%). This is primarily due to the natural conditions that necessitated the rotation of the road to follow the coastline, as the lengthening of some roads on the coast is one of the tourist elements of the area. For that, the turn indicator rises at the King Abdullah Road link, which reflects the negative deviation of the roads as its coefficient has reached (422%) highlighting the negative deviation of the road compared to the studied network roads.

Table 1: Indicator of Urban Roads and Streets Inflection of Dammam Metropolis in 2014. Source [10]

No.	Stretch of road	Actual length (km)	Straight length (km)	Indicator %
1	Abu Baker Arazi	3.42	3.39	100.88
2	Abu Baker Al Siddique	8.15	8.14	100.12
3	Abu Ubaida Bin Jarrah	4.52	4.52	100.00
4	Al Ashriah	2.09	2.8	100.48
5	Imam Ali Bin Talib	4.91	4.75	103.63
6	Imam Mohammad Bin Soud	6.06	6.04	100.33
7	Imam Mohammad Bin Abdol Wahab	6.90	6.88	100.29
8	Prince Saad Bin Abdulaziz	1.84	1.80	102.22
9	Prince Mansour	2.28	2.19	104.10
10	Prince Naif Bin AbudlAziz	11.00	10.75	102.32
11	9th Street	3.06	3.05	100.32
12	18th Street	7.40	6.55	112.97
13	28th Street	4.60	4.50	102.22
14	11th Street	3.10	3.06	101.30
15	15th Street	1.56	1.55	100.64
16	Alkhaleej Road	8.15	7.53	108.23
17	Dammam/Riyadh Highway	11.22	11.02	101.81
18	Shaikh Mohammad Bin Othaimeen	2.56	2.65	100.00
19	Dharan/Jubail Highway	17.11	16.94	101.00
20	Alabass Bin Abdul Motalib	2.14	2.14	100.00
21	Cornish Road Junction	2.25	2.17	103.68

No.	Stretch of road	Actual length (km)	Straight length (km)	Indicator %
22	Cornish Road Junction	5.43	3.57	152.10
23	Mutanabi	1.40	1.40	100.00
24	The Hospital	2.65	2.64	100.37
25	King Khaled	8.21	6.32	129.90
26	King Soud	11.51	10.91	105.49
27	King Abdulaziz	2.08	2.08	100.00
28	King Abdulaziz	7.07	7.02	100.71
29	King Abdulaziz	44.59	42.75	104.30
30	King Abdulallah	12.92	3.05	423.60
31	King Fahad Bin Abdulaziz	36.33	25.46	142.69
32	King Faisal	12.81	12.27	104.40
33	Bilal Bin Rabah	0.82	0.80	102.5
34	Hamza Bin Abdul Motalib	1.85	1.85	100.00
35	Khaled Bin Alwaleed	1.93	1.92	100.52
36	Prince Moteb Street	5.55	5.18	107.14
37	King Abdullah Ring Road	1.90	1.86	102.15
38	Othamn Bin Affan	6.25	5.87	106.47
39	Omar Bin Khattab	12.21	12.21	100.00
40	Omar Bin Abdulaziz	3.39	3.39	100.00
41	Amro Bin Alass	3.87	3.86	100.25
42	Fatima Alzahrra	1.90	1.89	100.52
43	Cooperation Council	18.48	18.68	100.85
44	The First	1.91	1.91	100.00
45	The Second	1.40	1.35	103.70
46	The 24th	2.50	2.50	100.00
47	The 5th	0.41	0.41	100.00
48	Ibrahim Alshattbi	1.73	1.70	101.76
49	Ibn Sinan Alkhafaji	0.62	0.62	100.00
50	Prince Turki	8.86	7.03	123.47
51	Prince Humoud Bin Abdulaziz	4.18	4.18	100.00
52	Prince Sultan	4.05	3.97	102.01
53	Prince Salman Bin Abdulaziz	3.18	3.18	100.00
54	Prince Faisal Bin Fahad	4.41	4.41	100.00
55	Prince Mugrin Bin Abdulaziz	2.81	2.81	100.00
56	Andulus	2.80	2.80	100.00
57	The 22nd	3.94	3.80	103.68
58	The 30th	2.83	2.77	102.16
59	The 15th	1.96	1.96	100.00
60	The 25th	2.45	2.45	100.00
61	The 4th	2.88	2.82	102.12
62	Riyadh St.	0.56	0.56	100.00
63	The 10th	1.28	1.28	100.00
64	The 20th	2.46	2.46	100.00
65	Al Quds	3.18	3.15	100.95
66	Cornish	5.17	4.39	117.76
67	King Khaled	12.94	12.09	107.03
68	King Soud	8.54	8.13	105.04
69	lKing Abdulaziz	2.46	2.40	102.5
70	lKing Fahad Bin Abdulaziz	46.70	20.04	233.03
71	lKing Fahad Bin Abdulaziz	8.41	8.16	103.06
72	King Faisal	9.78	9.60	101.87
73	King Abdullah Bin Abdulaziz	10.69	10.14	105.42
74	Khaled Bin Waleed	1.91	1.91	100.00
75	Salah Al-Din Al-Ayyubi	3.59	3.58	100.27
76	Tariq Bin Ziyad	3.35	3.34	100.29
77	Granada	1.16	1.16	100.00
78	Qurtbah	2.60	2.59	100.38
79	Cooperation Council	10.74	9.98	107.612

No.	Stretch of road	Actual length (km)	Straight length (km)	Indicator %
80	Mekkah St.	6.67	6.54	101.98
81	Mousa Bin Annosair	1.97	1.97	100.00
82	Ibn Alhayithm	1.06	0.93	113.97
83	Ibn Taimyiah	1.49	1.49	100.00
84	Abu Hadriah	17.27	15.50	111.41
85	Prince Ahmed Bin Abdulaziz	3.56	3.10	114.83
86	Prince Sultan	5.10	4.50	113.33
87	Prince Mohammad Bin Fahad	7.57	5.74	113.88
88	\Alkhazen	2.76	2.76	100.00
89	Dharan/Jubail Highway	4.97	4.15	119.75
90	King Soud	9.04	8.45	106.98
91	King Abdulaziz	37.49	35.50	105.60
92	\ King Fahad Bin Abdulaziz	17.10	14.3	114.75
93	King Fahad Bin Abdulaziz Conjunction	3.69	3.69	100.00
94	King Abdullah Bin Abdulaziz Conjunction	8.03	7.42	108.22
95	Omar Bin Abdulaziz	5.64	4.86	116.04
	Total	639.92	564.33	113.39

Network Density

Therefore, the network density can be analyzed as follows:

Density of Roads Relative to Area

In 2013, the density of the urban roads of the city of Dammam reached (562.62) kilometers per 1000 square kilometers. At the level of Dammam metropolitan cities, the density of urban roads in Dammam reached (738.24) km / 1000 km 2 in 2013 while the density of urban roads in the city of Al-Khobar increased for the same year to reach (898.02) km / 1000 km 2, meaning that it exceeds its two counterparts in Dammam metropolitan cities and can be attributed to the concentration of the urban area near the coast and commercial services, while the density of urban roads in the city of Dhahran reaches (210.69) km/1000 km2.

Density of roads in relation to the serviced area

In 2013, the average serviced area on urban roads in the cities of Dammam was (0.07) square kilometers of area per kilometer of urban roads, while the average in the city of Dammam for the same year was (0.7) square kilometers of area per kilometer of urban roads, whereas the average in the city of Khobar was (0.08) square kilometers of area per km of urban roads, and the average serviced area on urban roads in Dhahran was (0.04) square kilometers of area per km of urban roads.

Road density at the level of vehicles

The density of vehicles used for the urban network in a certain period of time can be expressed according to the size of the population, the area served by this network, and the lengths of roads in the selected area. In the following lines are some quantitative methods that are used to measure the efficiency and adequacy of transportation.

First, vehicle density in relation to roads: The share of vehicles for Dammam metropolitan area in terms of lengths of urban roads and streets in 2013 reached (0.018) kilometers of roads and urban streets for each vehicle, as the number of vehicles reached (44,1305) vehicles in 2014. The share of one longitudinal kilometer of vehicles in the city of Dammam is (0.01) vehicles/km, while the share of vehicles in the lengths of roads and streets reaches (0.005) vehicles/km, while the share of vehicles for urban roads and streets in the city of Dhahran is (0.002) vehicle/km.

Second, vehicle density in relation to area: The vehicle density for Dammam metropolitan area in 2013 reached (297.90) vehicles per square kilometer of area. As for the cities of Dammam, the vehicle density in Dammam reached (675.49) vehicles/km2 for the same year. While the density of roads increases, the urban density in the city of Al-Khobar for the same year as well reached (1716.80) vehicles / km 2, exceeding its counterparts in the cities of Dammam metropolitan, whereas the density of vehicles in the city of Dhahran reaches (772.90) vehicles / km 2.

Third, vehicle density in relation to the population: The vehicle density for Dammam metropolis in 2013 was (0.27) vehicles/person at the level of Dammam metropolitan cities. As for the vehicle density in Dammam for the same year was (0.47) vehicles/person, whereas the vehicle density was for the population in the city of Khobar is (0.79) vehicles/person, and for the density of vehicles in the city of Dhahran it reached 3.53 vehicles per person.

Road density at the population level and can be addressed as follows

First, the density of roads for the population: The density of urban roads for the city of Dammam in 2013 reached (5.17) kilometers per 1000 inhabitants. It is considered a high density if compared to the density of urban roads in other cities of the Kingdom such as Riyadh, where the density reached (0.0025) km/1000 population for the same year. While at the level of the cities of Dammam metropolitan area, the density of urban roads in the city of Dammam the same year reached (5.18) km per 1000 inhabitants, while the density of urban roads for the population in the city of Khobar was (4.16) km per 1000 inhabitants, and the density of roads is the city of Dhahran has a population of 9.63 km, with a thousand inhabitants.

Second, the average number of the population served by roads (indicator of the economic value of the roads):

The first Beta number (distance scale)

This indicator determines the levels of economic and social development that are directly proportional to its value. The indicator measures the relationship between the number of nodes, the number of links, and the number of network segments. By applying the above equation to the urban road network of Dammam in 2013, it is equal to the first Beta index (18.00).

III. Indicators of network structure analysis (degree of interconnectivity)

Beta Index

By applying this indicator to Dammam metropolitan roads, the degree of interconnection of the urban road network in 2013 is (1.42) indicating the existence of a complete and developed network for area under study.

Gamma Index

By applying the equation to the urban road network of Dammam in 2013, it is clear that the degree of interconnection of the road network in urban cities reaches (0.47). This means that the network is of medium interconnection and has not reached the limit of the complete network.

Alfa Index

By applying the above indicator to the area under study, it becomes clear that the degree of urban network interconnection in 2013 reaches (0.21), which means that the degree of network interconnection according to this indicator is weak, given that the number of parts of the network is one.

IV. Methods of analyzing the spatial relations of the transport network

Urban Nodes in the Network

According to the analytical study of the urban nodes of the metropolis of Dammam, the region includes (42733), most of which are surface intersections. Topology No. (2).

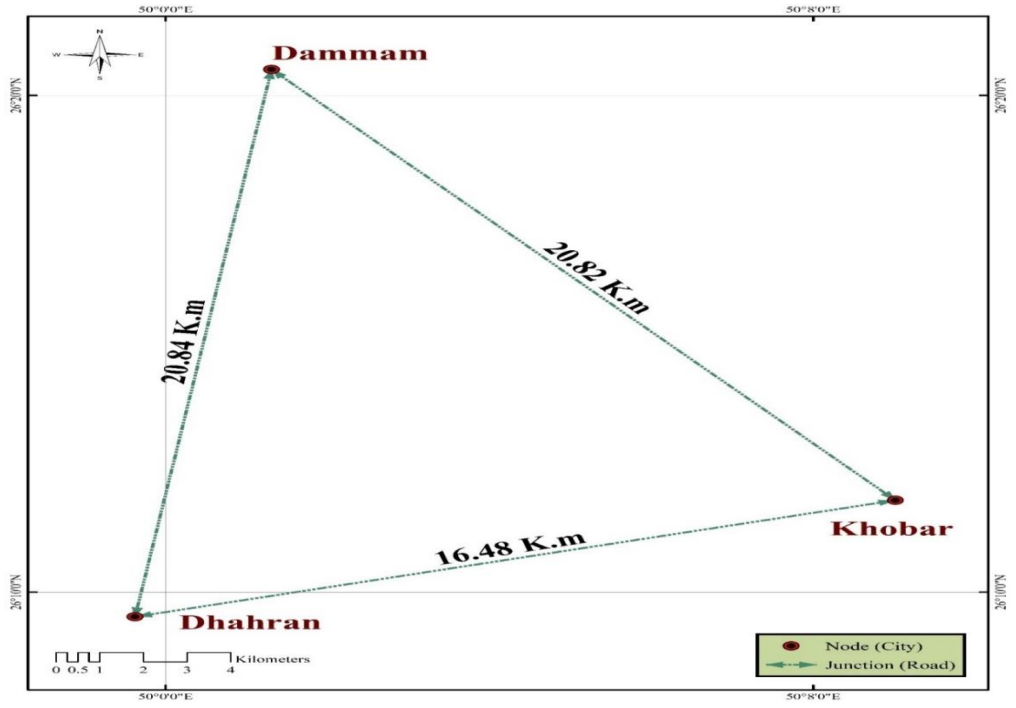


Figure 2: The Topological Figure of the Cities of Dammam Metropolitan in 2014

The Dammam metropolis was embodied as an important cultural center in the Kingdom in a topological form consisting of (42733) knots and (60734) connections, as shown in Figure 3. Despite this large number of

transport links and nodes in the metropolis of the metropolis, the city of Dammam - the mother of the Dammam metropolis - continued to adhere to the largest possible number of connections and transport nodes in the network. As it has (36534) links and (25889) nodes. Moreover, the developments that Al-Khobar witnessed during its long history prompted it to obtain (18705) links and (12837) nodes out of the total nodes and links. As for the city of Dhahran, it accounts for (5,495) connections and (4007) knots. Perhaps in determining what the cities of Dammam metropolis account for, each of the transport links and nodes has a fundamental explanation for what natural and human conditions played in the formation of the current picture of the network urban roads.

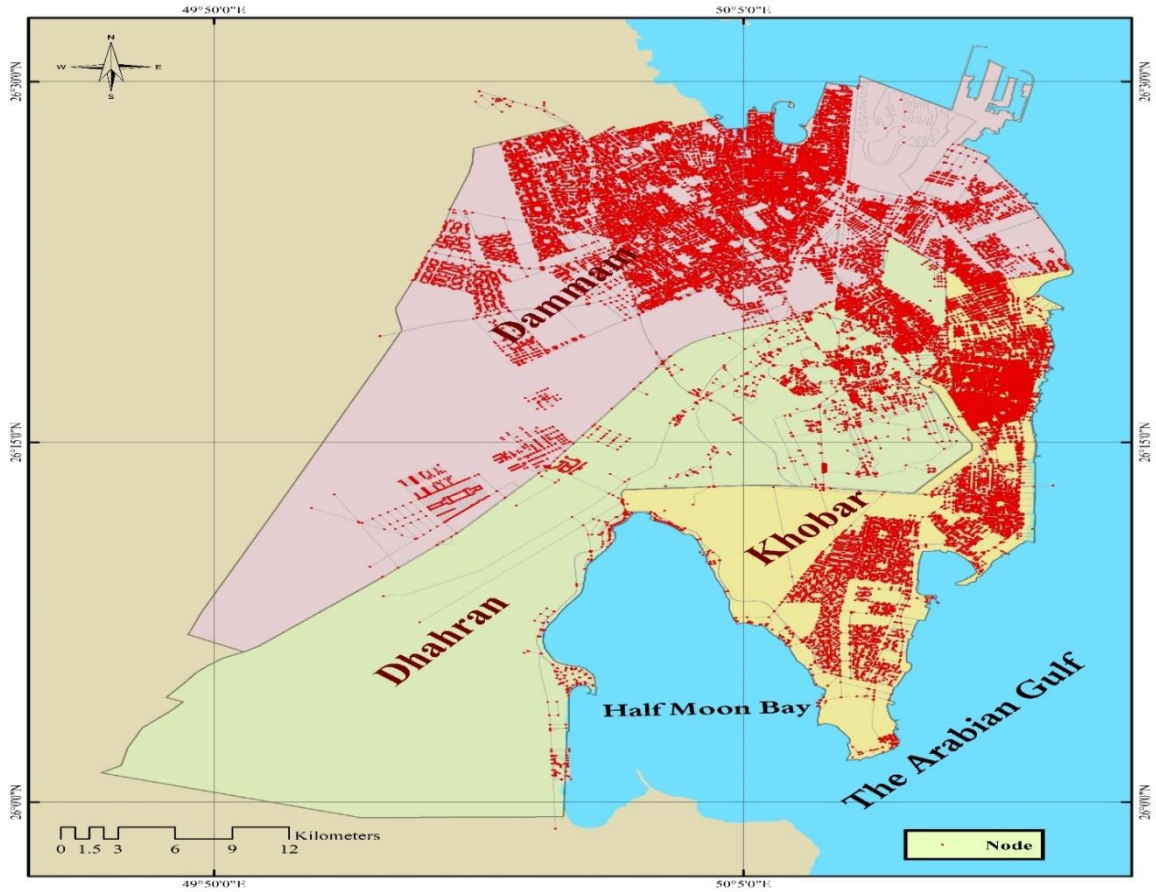


Figure 3: The Urban Contract of the Selected Area in 2014

Given that urban nodes arise as a result of the confluence of any two roads, such as surface intersections within cities, which are excluded from (free intersections because roads do not converge in them), as well as ports, airports, railway stations, as well as parking lots. Traffic-generating population, unlike what is witnessed by the road network, which depends in the output of the topological form mostly on the network's cities and villages and road service centers only and the links between them. Therefore, the research in the treatment of the topological form within the cities of the metropolitan of Dammam will depend on the transportation nodes represented by the transportation attractions represented in each of (Dhahran Mall - mass transit station - Dammam University - King Fahd University of Petroleum and Minerals - Railway Station) in the cities of Dammam metropolitan – as can be seen from Figure 4.

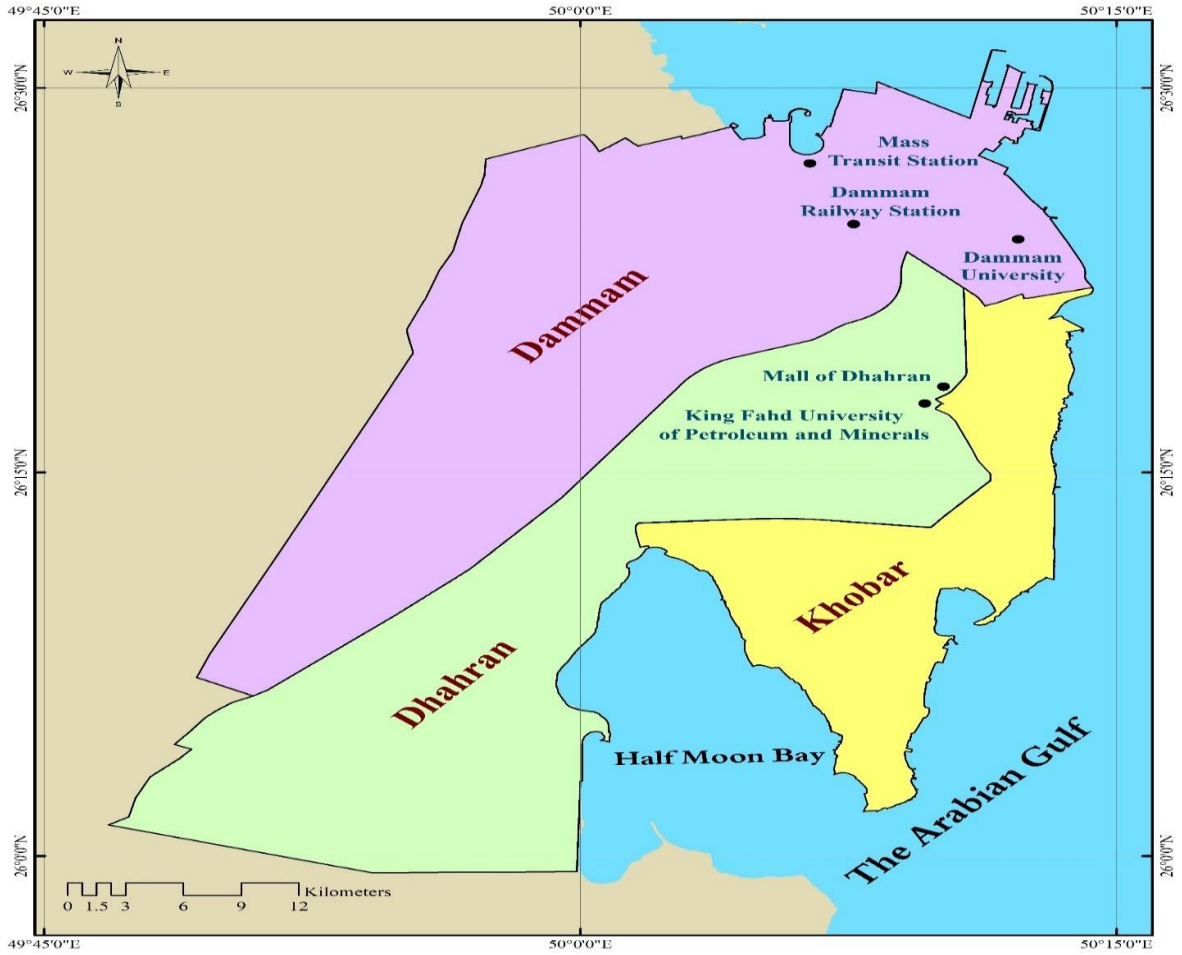


Figure 4: Traffic Generators in the Dammam Metropolitan Cities in 2014

This aspect of the network can be identified through two main entrances: the degree of centrality of nodes, and the accessibility between urban nodes in the network.

Centrality

The application of the Koenig indicator to the area under study requires the extraction of a matrix No. (2), through which it is clear that the average number of links reached (8 links/node), and by extrapolating the matrix data, it was possible to derive the following:

- Dhahran Mall and the mass transit station represent the first central nodes in the analyzed network, according to the Koenig index, it bears the least nodes with Koening number (15).
- Two nodes share in common the Koenig index that exceeds the general average (8), represented in the railway station and King Fahd University of Petroleum and Minerals.
- Dammam University Station is unique in its extreme location in the selected network, as it reaches the Koening number (17).

In addition, the location of the node may be at the maximum extension in the network in question. Yet,

according to the Quinning index, it may occupy previous positions for nodes located within the network, due to the good connection through direct methods with other nodes.

Table 2: The Degree of Centralization of the Contract in the Urban Road Network of the Metropolis of Dammam (According to Quinning Index in 2014) Source [Figure No. (3)]

To From	Dharan Mall	King Fahad Uni.	Dammam Uni.	Mass Transportation Station	Railway Station	Total	Rank
Dharan Mall	-	3	3	5	4	15	1
King Fahad Uni.	3	-	4	5	4	16	2
Dammam Uni.	3	5	-	3	6	17	3
Mass Transportation Station	5	4	3	-	3	15	1
Railway Station	3	4	6	3	-	16	2

Accessibility of urban roads in the network (Accessibility Index)

Traffic congestion has become noticeable and is constantly increasing due to the rise in ownership of vehicles and trucks on the urban road network that in turn increases the cost of transportation and movement in the urban area. Thus, it impedes the flow of traffic Therefore, the research aims to find a mechanism to measure the ease of access by measuring (journey time) as one of the forms of evaluating the transportation system, which can be invested in finding effective decisions in improving the performance of traffic on urban roads that are affected by several factors such as operational conditions, environmental quality, safety level and user comfort. It was possible to measure the performance of the traffic system on urban roads and streets in Dammam metropolitan cities in terms of efficiency for users through key elements such as travel time.

Travel time is one of the most important measures of traffic performance and ease of access on urban road networks. As the network's performance in achieving traffic can be measured by the time a road user needs to reach from source to target. To measure the journey time indicator in urban cities, eighteen roads were identified representing the scope of the study. As mentioned previously in Figure No. (5), the morning peak was chosen by counting the travel times (morning peak - midday peak - evening peak) on the road network and urban streets of Dammam metropolis in 2014, in order to reveal the extent of the variation in trip times for the morning rush on the arterial road links of the urban network. Then, such selections highlight the urban road connections that witness an increase in the journey time for the morning rush, and their impact on the ease of access of the population in the urban center, in an attempt to improve the traffic performance of Dammam metropolis.

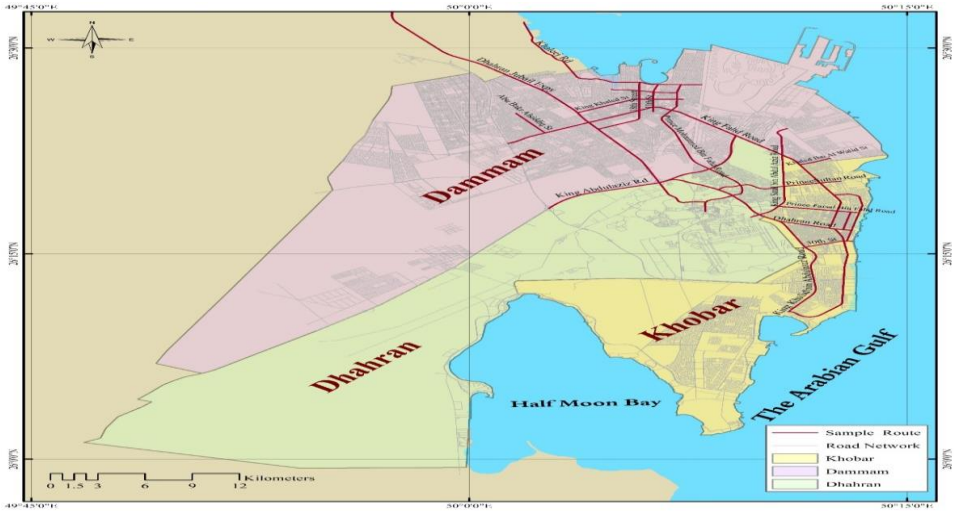


Figure 5: Arterial Roads in Urban Cities Within the Scope of the Study

By comparing the performance of traffic on the urban road network under study, according to the morning peak between the times of trips, it is clear from Figure No. (6) that the journey time varies clearly on the arterial road links under study, where the journey time on some road links is (9.58) second per minute for the link only forming a maximum travel time in the morning peak of urban cities. It is noticeable that journey times rise for the morning peak of some roads under study, such as the Jubail Expressway, where the journey time increases on road links within the urban center, while it decreases on the outer axes of Dammam metropolis for the same road, The journey time of the King Abdul Aziz Road in the link extending near the industrial cities in the west of Dammam specifically rises as well as the journey times of the remaining roads linking the cities of the study area. We conclude from the previous readings and measurements that the traffic performance is better in the inner axes close to the central areas of urban cities, while the performance decreases as we approach the outer areas of urban cities, due to the rise of journey times.

Figure 6: The Journey Time of the Urban Road and Street Network Under Study in 2014

Accessibility between urban nodes in the network (Accessibility Index)

Accessibility is a measure of the degree or proportion of the link of any site in the urban network with other sites across its lines, and these sites may represent centers of the network or sites of human - economic - service activities (Al-Samarrai, 2015, p. 15). Therefore, the study of movement through the network is based on the level of accessibility for the residents of the urban center, and the study of accessibility between urban nodes requires finding a matrix that represents the source and the target, as some spatial units were identified within the study region to test the ease of access between them. Through the "Best Route" scale, a network analysis is applied, as shown in Figure (7), the source places are represented in Badr neighborhood, Al-Amamrah neighborhood, Yarmouk neighborhood, Al-Khobar Al-Janoubia neighborhood, Al-Dana Al-Shamaliah neighborhood, while the target places are areas of attraction for the daily movement of urban residents are Dhahran Mall - Dammam University - King Fahd University of Petroleum and Minerals - mass transit station - railway station.

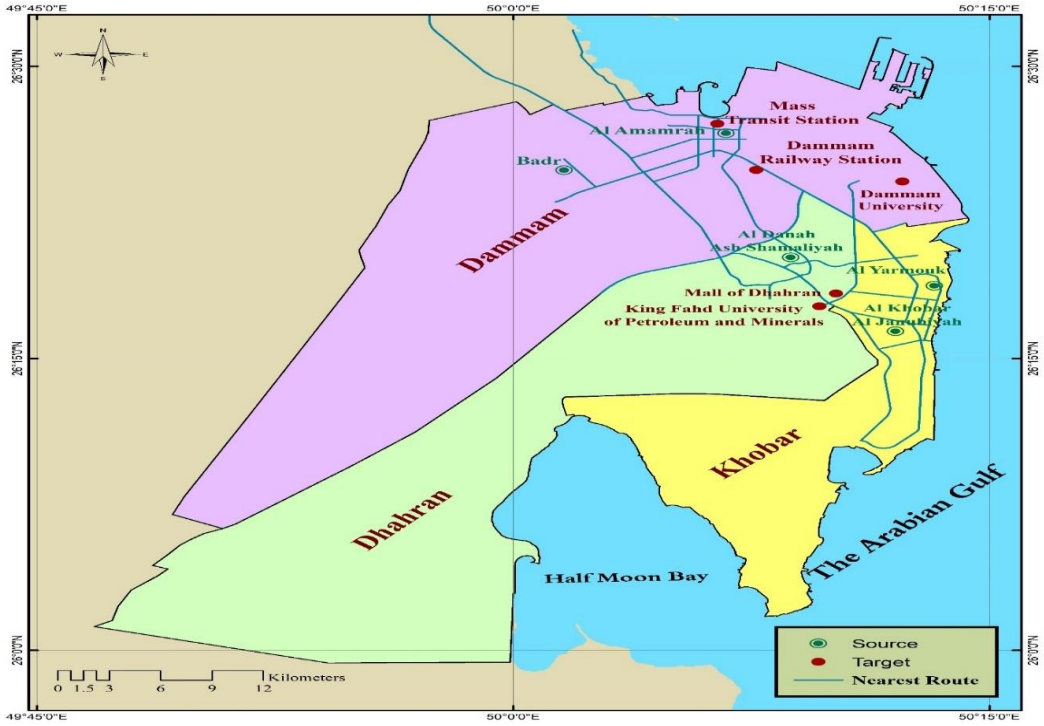


Figure 7: The Location of the Target and the Source in the Study Area in 2014. Source [10-11]

By applying the variables to the urban road network in Dammam metropolis, accessibility can be measured as follows:

1. The minimum distance between each site and the other sites

The distances between each site and the rest of the other sites are aggregated separately for the two peaks (morning-evening), so the site that relates to the lowest (shortest) distances (collective) is the site with the highest rank in the level of connectivity, and the same saying applies to (flight time) travel time between sites. According to the requirements of the research, (arterial roads and highways) were adopted in Dammam metropolitan area to measure the ease of access to sites by a unified means of transportation (vehicles),

according to the organization of a matrix representing the values of evidence of the ease of access of urban residents to different sites, as shown in Table No. (3), (4), (5) and (6).

Table 3: Ease of access for the population between the different sites of the morning rush according to the flight time in 2014. Source [10]

Sites (Neighbourhoods of the area under study)	Journey time in minutes (morning peak)				
	Attraction Sites for Transportation Movement				
	Dharan Mall	King Fahad Uni. For Petroleum & Minerals	Dammam Uni.	Mass Transportation Station	Railway Station
Badr District	15.6	16.3	15.33	1.65	6.8
Alamamera District	9.7	7.4	10.48	19.6	11.1
Yarmouk District	2	4.3	11.36	17	8.8
Dana Shamaliah District	9.9	6.2	14.7	23.5	15.3
Khobar Janoubiah District	54.7	25.4	69.47	74.86	51.1
Integrated Guide	3	2	4	5	1
Rank	15.6	16.3	15.33	1.65	6.8

Table 4: Population Ease of Access Between the Different Sites of the Morning Peak in 2014. Source [10]

Sites (Neighbourhoods of the area under study)	Distance kM (Morning peak)				
	Attraction Sites for Transportation Movement				
	Dharan Mall	King Fahad Uni. For Petroleum & Minerals	Dammam Uni.	Mass Transportation Station	Railway Station
Badr District	22.2	23.87	23	14.75	12.34
Alamamera District	25.6	27.2	15.6	1.2	4.9
Yarmouk District	9.6	11.1	12.3	25.7	19.4
Dana Shamaliah District	1.5	6.2	13.9	26.6	11.7
Khobar Janoubiah District	9.2	4.8	18.9	32.17	21.8
Integrated Guide	68.1	73.71	83.7	100.42	70.14
Rank	1	3	4	5	2

Table 5: Population Ease of Access Between the Different Sites of the Evening Peak in 2014. Source [10]

Sites (Neighbourhoods of the area under study)	Journey time in minutes (Evening peak)				
	Attraction Sites for Transportation Movement				
	Dharan Mall	King Fahad Uni. For Petroleum & Minerals	Dammam Uni.	Mass Transportation Station	Railway Station
Badr District	16.2	17.11	15.44	12.4	8.3
Alamamera District	15.6	16.4	14.78	1.6	7.65
Yarmouk District	11.1	7.5	10.3	17.6	10.4
Dana Shamaliah District	2.6	4.7	10.7	13.9	6.7
Khobar Janoubiah District	13.5	8.5	15.4	22.7	15.5
Integrated Guide	59	54.21	66.62	68.2	48.55
Rank	3	2	4	5	1

Table 6: Population Ease of Access Between the Different Sites of the Evening Peak in 2014. Source [10]

Sites (Neighbourhoods of the area under study)	Distance kM (Evening peak)				
	Attraction Sites for Transportation Movement				
	Dharan Mall	King Fahad Uni. For Petroleum & Minerals	Dammam Uni.	Mass Transportation Station	Railway Station
Badr District	23.8	30.6	23	11.8	12.3
Alamamera District	17.3	24	16.5	1.2	5.8
Yarmouk District	9.6	11.1	12.3	25.1	19.5
Dana Shamaliah District	1.4	5.3	16.2	17.4	11.7
Khobar Janoubiah District	9.5	5.2	14.8	27.6	21.9
Integrated Guide	61.6	76.2	82.8	83.1	71.2
Rank	1	3	4	5	2

In the context of measuring the level of connectivity of the transportation of attraction areas with the neighborhoods of selected area, the results of the level of connectivity of each site in the concerned region are obtained. As the levels were grouped for each of the sites selected with the areas of other transportation attractions, as shown by the composite matrix Table No. (7) and figures No. (8), (9), (10), (11) and (12) that highlight the closest paths from the transportation attraction areas to the other sites under study. The following can be drawn:

- Dhahran Mall records with the Al-Dana North neighborhood in its connection level, according to time and distance, the shortest distance and cumulative time between the districts in concern, while Badr district records the largest time and cumulative distance, where the cumulative journey time for the morning and evening peaks reaches (33.7) minutes, with an aggregation distance of up to to (46) km.
- Al-Dana Al-Shamaliah neighborhood in its level of contact according to time with King Fahd University of Petroleum and Minerals has the lowest cumulative time among the districts under study, while Al-Khobar Al-Janoubia neighborhood is recorded with the lowest cumulative distance in the level of its contacts, according to the distance with King Fahd University of Petroleum and Minerals. As Badr district represents the largest distance and cumulative time of the morning and evening peaks with the site of King Fahd University of Petroleum and Minerals, where the cumulative flight time reaches (35.31) minutes, and the cumulative distance reaches (54.47).
- The site of the University of Dammam with the Yarmouk district records its level of connection, according to the time and distance, with the least time and cumulative distance between the districts under study (46) km.
- Al-Amamra district obtains its level of connection according to the time and distance with the location of the mass transit station with the least time and cumulative distance in the selected districts, and the

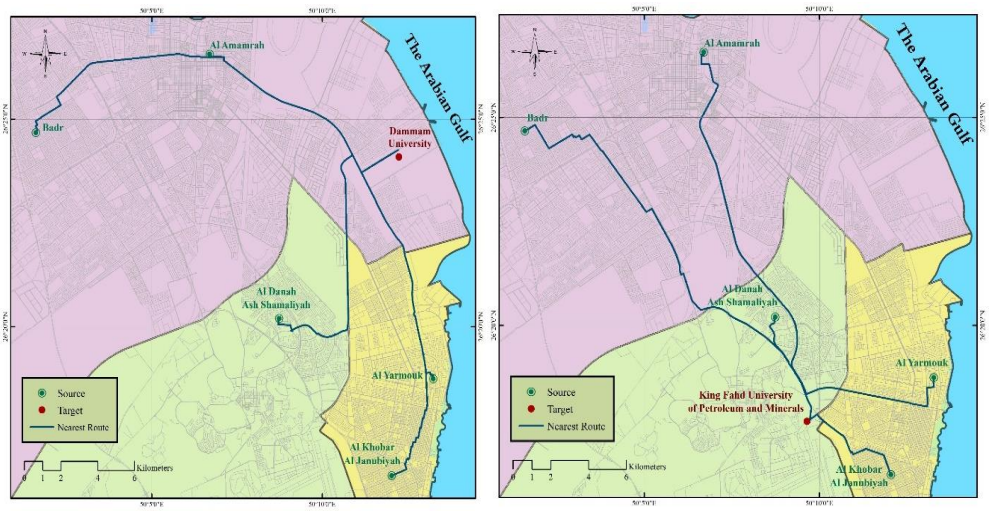
southern district of Khobar records the largest distance and cumulative time, reaching (46.2) minutes, and a distance of 59.77 km for both peaks.

- The location of Al-Amamra district is recorded among the neighborhoods of the area under study with the railway station in its level of connection, according to time, with the lowest collection time with a cumulative distance and time reaching (30.8) minutes, and a distance of (43.7) km for both peaks.

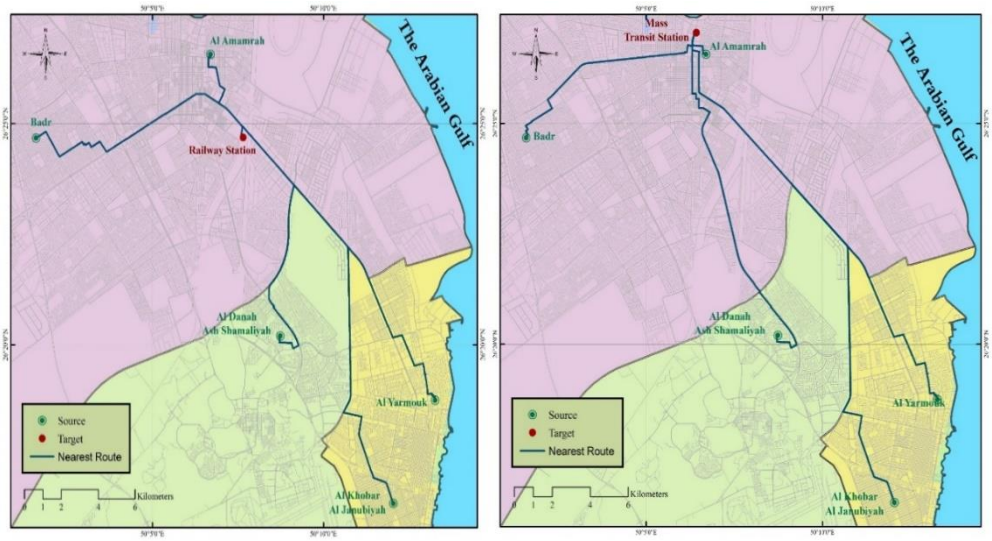
Table 7: Matrix Measuring the level of Connectivity of Sites According to the factors of Time and Distance In 2014. Source [tables No (2) (3)(4)(5)]

Sites (Neighbourhoods of the area under study)	Attraction Sites for Transportation Movement									
	Dharan Mall		King Fahad Uni. For Petroleum Minerals		&Dammam Uni.		Mass Transportation Station		Railway Station	
	Time Total	Distance Total	Time Total	Distance Total	Time Total	Distance Total	Time Total	Distance Total	Time Total	Distance Total
Badr District	33.7	46	35.31	54.47	33.4	46	25.51	26.55	4.17	24.64
Alamamera District	31.2	42.9	32.9	51.2	30.11	32.1	3.25	2.4	14.45	10.7
Yarmouk District	20.8	19.2	14.9	22.2	20.78	24.6	37.2	50.8	21.5	38.9
Dana Shamaliah District	6.4	2.9	9	11.5	22.6	30.1	30.9	44	15.5	23.4
Khobar Janoubiah District	23.4	7.18	14.7	10	30.1	33.7	46.2	59.77	30.8	43.7

(a) (b)



(c) (d)



(f)

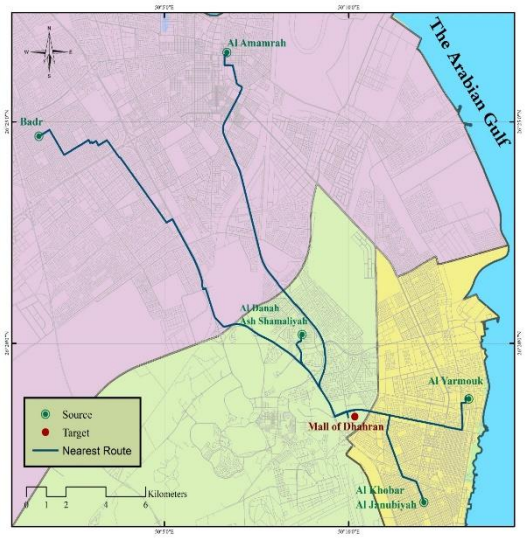


Figure 8: The closest paths from the source to the locations of the Neighborhoods Involved in the Study in 2014

2. Adopting the largest population as the most connected via network lines

These centers are arranged in descending order based on the number of residents, and the study postponed highlighting the population of the neighborhoods concerned with the study in knowing the number of residents of the neighborhoods, where Badr neighborhood leads with the largest number of residents of the neighborhoods concerned with the study, while the number of residents of Yarmouk neighborhood decreases, which cannot be subjected to evaluation in The likely accessibility, as it does not represent the population of the transport nodes, and the data in Table No. (8) gives the most accessible accessibility in the neighborhoods of the Dammam metropolitan areas, according to an estimate in 2014.

Table 8: The Most Accessible Population the Year 2014. Source [13]

Districts Examined	Population Numbers (per capita)	Rank
Badar District	57123	5
Alamamera District	10985	3
Khobar Janoubiah District	14274	4
Yarmouk District	897	1
Dana Shamaliah District	15049	2

Weighted Accessibility Scale

Assembling the ranks for each center with the rest of the other sites for the morning and evening peaks according to time and distance - that is, according to the aforementioned measurements. The studied urbanization, as shown in Table (9).

Table 9: Likely Reachability for a year 2014. Source [tables No (2) (3)(4)(5).]

Transport Noed	Rank				
	Time (AM)	Distance (AM)	Time (PM)	Distance (PM)	Total
Dharan Mall	3	1	3	1	8
King Fahad Uni. For Petroleum & Minerals	2	3	2	3	10
Dammam Uni.	4	4	4	4	16
Mass Transportation Station	5	5	5	5	20
Railway Station	1	2	1	2	6

To sum up, the spatial analysis, looking at the sites under study, indicates that the Badr district was not recorded with the least time and cumulative distance, due to the location of the district in the west of the selected area, especially in the city of Dammam. Therefore, far from the central areas of urban cities that witness a concentration in administrative, commercial and educational services It is evident that the residents of Badr neighborhood and the neighborhoods of western Dammam in general suffer from an increase in travel times. Thus, creating a pressure on certain sectors of the road network and urban streets, especially highways that penetrate the urban fabric of Dammam metropolis, then the occurrence of traffic jams on those roads are for the morning and evening peaks, work to reduce the efficiency of highways in urban centers.

By analyzing Figure (9) that represents a topological form of urban nodes in the analyzed area and its relevant neighborhoods, it is noticeable that by comparing the distance in the two previously mentioned tables for the morning and evening peaks of the source and target and the distance shown in the figure below, it becomes clear the negative deviation of the linking methods between the source and the target necessitates the importance of working on the distribution of various services in the western city of Dammam. Especially, the western metropolitan area that represents the future area to absorb the rise of the population, in order to avoid expected future problems on the urban road network. For that, the topological form of the source and target gives a range of possibilities of benefiting from the creation of road links by raising the efficiency of the quality of urban

roads and streets, and not relying on highways crossing the city of Dammam.

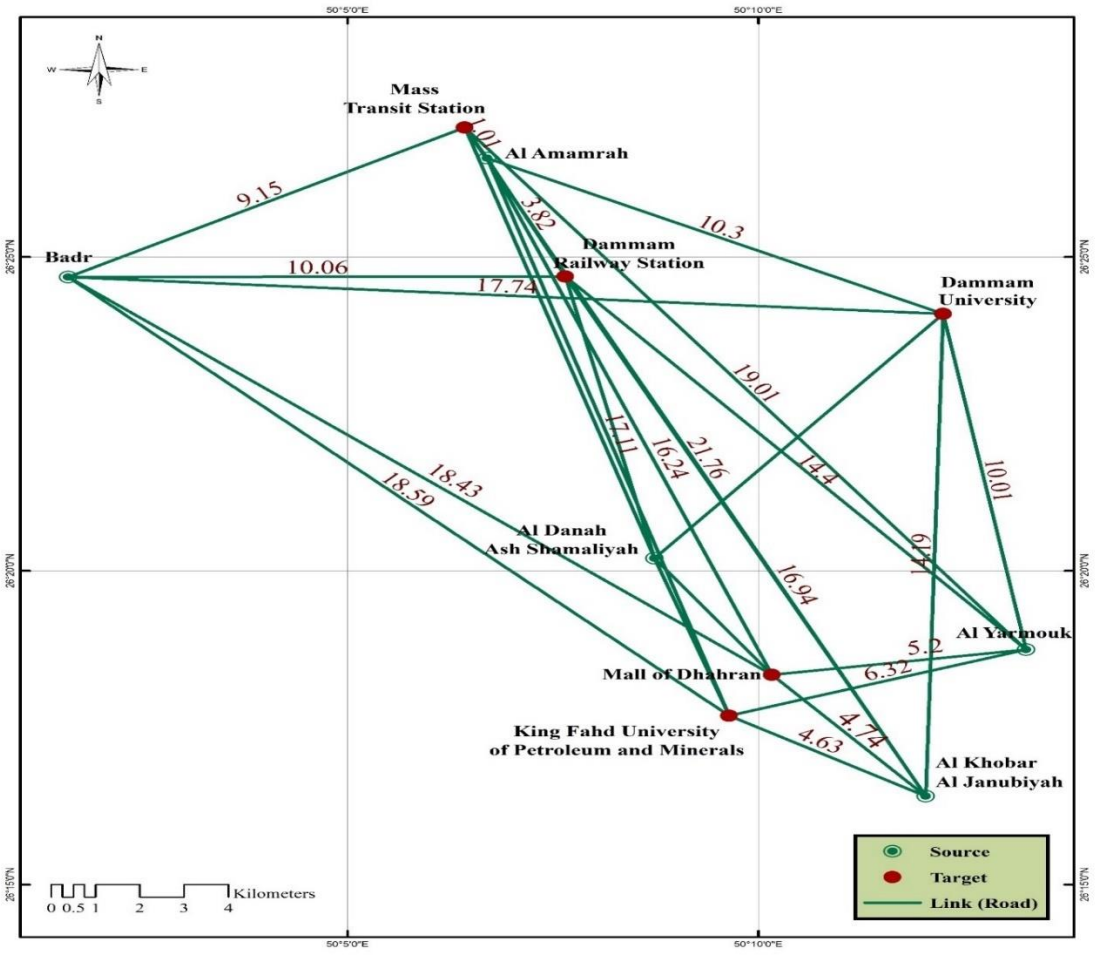


Figure 9: The Topological Form of The Source and The Target in the Area under the Scope of the Study

11. Conclusions

It has been shown from the study of the quantitative analysis of the urban road network of the metropolis of Dammam, it is clear that the turn index for the examined area scored (113%), as a result of the plateau nature in the cities of the metropolis of Dammam. As for the density of the urban roads of Dammam in 2014, it reached (562.62) linear kilometers per 1000 square kilometers. As for the density of Damam urban roads in 2014, it reached (5.17) kilometers per 1000 inhabitants This density amount is high when compared to other regions of the Kingdom. which is a high density in comparison to the density of urban roads in other cities of the Kingdom. By applying the beta indicator to the roads of the metropolitan of Dammam, it was found that the degree of interconnection of the urban road network is (1.42) that indicates the existence of a complete and developed network, whereas by applying the gamma index to this urban road network in 2014, it is clear that the degree of interconnection of the road network in urban cities reaches (0.47) – meaning that the network is partially-connected.

References

First: Arab sources and references:

[1]. Al-Ruwaithi, Mohammed Ahmed (1992) *Road Network in Medina, Analytical Geographical Study*, Paper for the Fourth Geographical Symposium, Um al-Qura University. p. 20

[2]. Al-Samarrai, Majid Maluk (2015*) Contemporary Transport Geography and Computer Applications*, Al Yazuri Scientific Publishing and Distribution House, Amman.

[3]. Al-Samak, Mohammed Azhar; Al-Obaidi, Ahmed Hamed; and Al-Hayali, Mohammed Hashem (2011) *geography of transport between methodology and application***,** Al Yazuri Scientific House, Amman, Jordan. p. 64

[4]. Qadid, Mahmoud Hamidan (2009) *Urban Transport Planning*, Unpublished Master's Letter, Arab Academy in Denmark, Faculty of Economics, Denmark.p.9

[5]. Juicy, Hamad Raafat, Burgan, Mohammed Abdul Lah (2018) *Analysis of the characteristics of the road network in Hebron using GIS*, Journal of Geographic Research Issue 27, Department of Geography, National University of Success, Nablus, Palestine.

[6]. Ministry of Economy and Planning (2010) *Preliminary results of the general census of population and housing***,** General Authority for Statistics, Saudi Arabia**,** Riyadh.

[7]. Ministry of Interior (2014) *Data on the number of traffic accidents and vehicles registered in the cities of Dammam***,** unpublished data, public security, traffic in the eastern region of Dammam, Dammam.

[8]. Ministry of Municipal and Rural Affairs (2010) *Map of the administrative boundaries of the capital of Dammam*, unpublished map, Secretariat of the Eastern Region, General Directorate of Urban Planning, Dammam.

[9]. Ministry of Municipal and Rural Affairs (2014) *Baseline map of the urban scope of the cities of The Capital of Dammam*, unpublished map, Secretariat of the Eastern Region, General Directorate of Urban Planning, Dammam.

[10]. Ministry of Municipal and Rural Affairs (2014) *Time of journey for urban roads in the capital of Dammam*, unpublished data, Secretariat of the Eastern Region, Reconstruction and Projects Agency, Dammam.

[11]. Ministry of Municipal and Rural Affairs (2014) *Map of municipalities and neighborhoods of the cities of Dammam***,** unpublished map, Secretariat of the Eastern Region, General Directorate of Urban Planning, Dammam.

[12]. Ministry of Municipal and Rural Affairs 2014 *Data on the development and population of the neighborhoods of the cities of The Capital of Dammam***,** unpublished data, Secretariat of the Eastern Region, General Directorate of Urban Planning, Dammam.

[13]. Talib, Mohammed, Ibrahim Abdul Al-Futah (2016*) Urban Road Network in Mecca, using GIS, Study in Transport Geography*, Master's Thesis in Literature, Department of Geography, Mansoura University.

Second: Foreign references:

[14]. Ranya a Fadlalla Abdalla Elsheikh,Abdelrahim Eilhagm,Salah Eddeen Kidir Sideeg,Aisha Elhadi Mohammed, Nagla Ali Gism, Mohamed Sharif Abd Allah (2016) ,Route Network Analysis in Khartoum, SUST journal of Engineering and Computer Science (JECS), Vol.17, No.12016.

[15]. Idhoko K.e، Ndiwari، E.L، Ogeh, V.C.، Ikegbulam, S. C.، (2016) *Urban Road network analysis of Yenagoa، Bayelsa State Use GIS*، International journal of Engineering and Computer، Volume 5، Issue 1 January 2016، Pp 15605-15615.

[16]. Zhao Tian, Limin JIam, Honghui Dong, Feisu Zundong Zhang (2016) Analysis of Uraban Road Traffic Network Based on Complex Network, Procedia Engineering Volume 137, (2016) Pp 537-546.

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