

Paths Planning For AL-Ramdi Intercity Road Using GIS Tool

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ABSTRACT

Transportation planning process (find the best route) can be considered as a strategic, important and complex issue in the same time, due to the need of collecting information and analyzing data to obtain the optimum network (journey of shortest route), ie., minimizing time, coast, fuel, noise, and air pollution.

(GIS), the network should be analysis to find the best route based on shortest distance with minimum time between the origin and destination of journey by using software's algorithm. Moreover, the ability of GIS to generate detailed directions along the route, providing as-you-need-it solutions for common problems.

The algorithm divides the network into nodes (ie, start, and lines intersection) and the paths between such nodes are represented by lines. In addition, each line has an associated cost representing the cost (length or time) of each line in order to reach a node. There are many possible paths between the origin and destination, but the path calculated depends on which nodes are visited and in which order.

A case study of Al-Ramadi city is choosed for this study, it lies in the west part of Al-Iraq; it's the capital of Al Anbar Governorate and is situated at the intersection of the Euphrates River and Al Warrar River's Channel, northwest of Al-Habbaniyah Lake. The city is 110 km west of Baghdad, 46 km west of Al-Fallujah, and 283 km east of Al-Rutbah. It lies on the major paths to Syrian and Jordanian borders, so it occupies a strategic planning concern.

The objectives of this study is to find the shortest time (least cost path) between zones of Al-Ramadi city, for that the city of Al-Ramadi is divided into (5) Traffic Analysis Zones (TAZ), the centered of each zone is obtained in order to compute the shortest time from the center of first zone (origin) to the center of second zone (destination).

The result of this study is a matrix,It shows the least time to travel between the 5 (TAZ), these results can be considered very important to implement Intelligent Transportation System (ITS).

Keywords: Geographic information systems, Network analysis, Al-Ramadi City.

ايجاد المسارات المثلى لشبكة النقل داخل مدينة الرمادي باستخدام برنامج نظم المعلومات الجغرافية

الخلاصة

تعتبر عملية تخطيط النقل (اختيار افضل مسار) من المهام الاستراتيجية و المهمة و المعقدة في نفس الوقت لما تتطلبه من جمع للمعلومات و تحليل البيانات للوصول الى الشبكة المثلى من حيث المسارات ذات الرحلات القصيرة لتوفير الوقت و بالتالي توفير الكلفة و الوقود و تقليل التلوث و الضوضاء. باستخدام برنامج نظم المعلومات الجغرافية يمكن تحليل الشبكات و ايجاد احسن المسارات باعتبار اقصر مسافة او اقل زمن للرحلة بين نقطة بداية و نهاية الرحلة من خلال خوارزمية البرنامج. بالاضافة الى امكانية البرنامج على توليد اتجاهات مفصلة على طول المسار. الخوارزمية تقسم الشبكة الى عقد (موقع ارتباط الخطوط، البداية و النهاية) و المسارات بين هذه العقد تمثل بواسطة خطوط. بالاضافة الى ذلك، كل خط له كلفة محددة تمثل اما بمسافة الخط او بالزمن المستغرق للوصول الى العقدة. يوجد عدد من المسارات بين بداية الرحلة و نهايتها، و لكن اقصر مسار يعتمد على اقل زمن للخطوط (اقل كلفة).

لاغراض هذه الدراسة فقد تم اختيار مدينة الرمادي، تقع المدينة في الجزء الغربي من العراق و هي عاصمة محافظة الانبار و موقعها في تقاطع نهر الفرات مع قناة نهر الرار، شمال غرب بحيرة الحبانية. المدينة تقع على بعد 110 كم غرب بغداد، 46 كم غرب الفلوجة، و تقع على مسافة 283 كم شرق الرطبة. ايضا تقع مدينة الرمادي على الطريق الرئيسي المؤدي الى الحدود السورية و الاردنية، لهذا تحتل موقع ستراتيجي مهم.

غرض هذه الدراسة هو ايجاد اقل زمن للرحلات المتولدة في مدينة الرمادي (اقل كلفة للمسار)، من اجل ذلك تم تقسيم مدينة المادي الى 5 مناطق، تم تحديده مركز كل منطقة من اجل حساب زمن الرحلة من مركز المنطقة الاولى (المنشأ) الى مركز المنطقة الثانية (المقصد). نتيجة هذه الدراسة هو مصفوفة تبين اقل زمن للرحلة بين المناطق الخمسة لمدينة الرمادي، يمكن اعتبار هذه النتائج ذات اهمية بالغة لغرض تطبيق نظام النقل الذكي.

INTRODUCTION

A GIS is a digital computer application designed for the capture, storage, manipulation, analysis and display of geographic information. Geographic location is the element that distinguishes geographic information from all other types of information. Without location, data are termed to be non-spatial and would have little value within a GIS. Location is, thus, the basis for many benefits of GIS: the ability to map, measure distances, and tie different kinds of information together because they refer to the same place (Longley et al., 2001)[1].

GIS-T, the application of geographic information science and systems to transportation problems, represents one of the most important application areas of GIS-technology today.

The urban transportation systems are very complex in nature, due to the fact that they combine different modes of transportation over a limited space in high-density areas with increasing transport demand. With variety of information needed in the field of transportation, GIS have long been recognized as a valuable tool for the representation and analysis of transportation networks and related activities (Nagar et al., (2007))[2].

Transportation data encompasses a wide range of spatial data entities that are fundamental to many GIS and cartographic applications. Transportation data is normally considered a key element of base maps and serves as essential reference data in this context. Besides its role as reference data, transportation data is at the core of applications, such as emergency response, routing, urban and regional planning, public transport, municipal service provision and general purpose mapping (Rodrigue, 2005)[3].

In general, topics related to GIS studies in the field of transportation can be grouped into three categories (Rodrigue, 2005)[3]:

- Data representations. How can various components of transport systems be represented in a GIS?
- Analysis and modeling. How can transport methodologies be used in a GIS?
- Applications. What types of applications are particularly suitable for GIS?

Data representation is a core research topic of GIS. Before a GIS can be used to tackle real world problems, data must be properly represented in a digital computing environment.

GIS integrate graphical user interfaces for data visualization with spatial databases. These systems allow the association of network elements to attributes like street names, lengths and traffic directions, among others, commonly used as input for location and transportation problems (Filho, et. al. (2006))[4].

Route location has been always used by common people in navigating from one place (origin) to another (destination). The using of GIS-Network Analysis software determines the best route by using an algorithm which finds the shortest path (least cost route). The algorithm divides the network into nodes (where lines join, start or end) and the paths between such nodes are represented by lines. In addition, each line has an associated cost representing the cost (length or time) of each line in order to reach a node. There are many possible paths between the origin and destination, but the path calculated depends on which nodes are visited and in which order (Karadimas et al., (2007))[5].

In addition to that one of the main benefits of using this technique (network application of GIS) in transportation is in the implementation of ITS which need to find the optimum route for travelling between any two points (origin and destination).

ITS represents the integrated application of advanced information, electronic, communications, and other technologies to address surface transportation problems. Freeway surveillance and incident management, and transit fleet management are all examples of new innovations in transportation systems and services. Computerized traffic signals, variable message signs, electronic “smart cards” for tolls and transit fares are all examples of new innovations in transportation products. Cruise control, trip planning, emergency notification and collision avoidance are examples of in-vehicle systems.

STUDY AIM

The application of GIS to a diverse range of problems in transportation engineering is now well established. It is used for the analysis of both spatial and non-spatial data and for solving important problems of networking, so the main goals of this study are to:

- 1- Use ArcGIS 9.3 software to solve important problems of the network in Al-Ramadi city, which has congestion in their arterial roads network.
- 2- For each zone, the attraction and generation of trips are determined, and then the shortest routes (minimum cost routes) between these zones are investigated using GIS-network analysis.
- 3- A network is to be made that the shortest path for every origin-destination pair is on the arterial roadways, so that the center of each zone is determined in order to compute the shortest route from center of first zone (origin) to center of second zone (destination).

NETWORK REPRESENTATION

In GIS-Network Analysis software the network is made up of a series of points and lines connecting these points. The points, or network nodes, represent the intersections within the street system. The lines, or network links, represent the streets.

Network Analysis in GIS software uses the Dijkstra’s Algorithm (Dijkstra 1959) [6] in order to find shortest path and it can be generated based on two criteria (Lakshumi et al 2006)[7]:

Distance criteria: The route is generated taking only into consideration the length of the links in the origin-destination trips. The volume of traffic in the roads is not considered in this case.

Time criteria: The total travel time in each road segment should be considered as the runtime of the vehicle in each road segment. The runtime of the vehicle is calculated by considering the length of the road and the speed of the vehicle in each road. The volumes of traffic are taken into account in each road segment.

Using the second criteria, several routes could be generated during a random day in order to compare the total travel time between these predefined time intervals. Hence, routes could be generated during the day time or during the night time in order to compare the total travel time in these different time intervals during the day.

Dijkstra's algorithm is the simplest path finding algorithm, even though these days a lot of other algorithms have been developed. Dijkstra's algorithm reduces the amount of computational time and power needed to find the optimal path. The algorithm strikes a balance by calculating a path which is close to the optimal path that is computationally manageable (Olivera 2002)[8].

The algorithm breaks the network into nodes (where lines join, start or end) and the paths between such nodes are represented by lines. In addition, each line has an associated cost representing the cost (length or time) of each line in order to reach a node. There are many possible paths between the origin and destination, but the path calculated depends on which nodes are visited and in which order. The idea is that, each time the node, to be visited next, is selected after a sequence of comparative iterations, during which, each candidate-node is compared with others in terms of cost (Stewart 2004)[9].

The following comprehensible example, which is an application of the algorithm on a case of 6 nodes connected by directed lines with assigned costs, explains the steps between each iteration of the algorithm (Figure 1). The shortest path from node 1 to the other nodes can be found by tracing back predecessors (bold arrows), while the path's cost is noted above the node.

STUDY AREA

The city of Al-Ramadi which located at the middle west of Al-Iraq; it's the capital of Al Anbar Governorate and is situated at the intersection of the Euphrates River and Al Warrar River's Channel, northwest of Al-Habbaniyah Lake. The city is 110 km west of Baghdad, 46 km west of Al Fallujah, and 283 km east of Al-Rutbah. It lies on the major paths to Syrian and Jordanian borders, so it occupies a strategic planning concern. See Figures (2). The Euphrates River passes at the upper limit of the city, whereas, Al-Warrar river divides the city into two parts. The study area is a less developed urban/suburban region and is expected to get high development in the future.

In this research, GIS tool will be used in order to obtain the best routes (shortest routes) for all the generated trips in Al-Ramadi city, the Google earth's map is used for the purpose of this research. Al-Ramadi city includes all major city highways and roadways which form the skeleton of Al-Ramadi's transportation network.

In this study, Al-Ramadi city and the nearest areas are divided into two areas in order to know the important residential surrounding area, see figure (3). Table (1) shows land use pattern of Al-Ramadi city.

Many governmental institutes are concentrated in the center of the city, which reduce the resident density in that area.

Al-Ramadi City subjected to many patterns of growth during the past decades, as shown in Table (2). According to the Iraqi Censuses, the population of Al-Ramadi city has grown from 9919 persons in 1947 to 230500 persons in 2009.

Significant commercial and residential developments have occurred for the past several years, which have increased traffic volumes on the study area's transportation system, and very significant additional development is expected to happen [Abdjabbar, (2005)][11].

In this study, the city of Al-Ramadi is divided into (5) Traffic Analysis Zones (TAZ), each zone can be considered as internally homogeneous sector. These zones are shown in Figure (4), and are divided based on considerations of land use, demographics and Al-Ramadi street system.

Abdjabbar, (2005) [11] reported that the TAZ define geographic areas which are mainly used to relate travel demand to socioeconomic characteristics. There are several basic principles which are used in selecting the boundaries of TAZs. The road network to be modeled is a prime consideration. The second consideration is that zones must be small enough to identify travel on important corridors. Geographic features frequently serve as natural boundaries of TAZs, reflecting a natural barrier to travel. In areas of greater interest, the TAZs should be smaller so that the travel volumes are reflected on the network links. The above principles establish guidelines for selecting TAZ boundaries. As may be expected, it is not always possible to satisfy each principle for every TAZ when modeling an actual transportation network.

ORIGIN-DESTINATION MATRIX OF AL-RAMADI CITY

Herein the Origin-Destination (O-D) matrix of Al-Ramadi city which are set as an input file. This matrix is 5*5 for internal trips, each element in this matrix represents the number of trips between the i^{th} row and j^{th} column of the matrix. Table 3 represents the O-D matrix of Al-Ramadi City. The matrix of 5*5 elements is created to contain all the trips within the city. The east side of Al-Warrar River's Channel is divided into 2 zones including the CBD (Central Business District) area. This side includes many trip attractors in the morning peak like CBD area, main hospital, province and Municipal buildings, and many services. The west side of the city is divided into 3 zones which are of less density than the east side but it includes the main traffic generator which is the university, and some warehouses structures.

MAJOR ARTERIALS IN AL-RAMADI CITY

The major arterials in the city are shown in Figure (5) and Table (4).

Research Methodology

GIS-Network analysis software determines the best route by using an algorithm which finds the shortest path, developed by Dijkstra, (1959) [6]. The algorithm breaks the network into nodes (where lines join, start or end) and the paths between such nodes are represented by lines. In addition, each line has an associated cost representing the cost (length) or (time) of each line in order to reach a node. There are many possible paths between the origin and destination, but the path calculated depends on which nodes are visited and in which order. The idea is that, each time the node, to be visited next, is selected after a sequence of comparative iterations, during

which, each candidate-node is compared with others in terms of cost. Finding the best route can be generated based on two criteria Lakshumi, et. Al. (2006) [7]:

- 1- Distance criteria: The route is generated taking only into consideration the location of the O-D. The volume of traffic in the roads is not considered in this case.
- 2- Time criteria: The total travel time in each road segment should be considered as the: Total travel time in the route = runtime of the vehicle. The runtime of the vehicle is calculated by considering the length of the road and the speed of the vehicle in each road.

Here, in this study, the using of time criteria was choosed in order to determine the best route (shortest route).

The volume of traffic is counted; morning peak is taken into account because it is higher from evening peak. Figure (6) and table (5) show the volume of traffic in the morning peak.

The center of each zone is coordinated using GIS tool in order to compute the travel's time from the center of first zone (origin) to the center of another zone (destination). Figure 7 show the center of zones in Al-Ramadi city.

As mentioned in the previous paragraph, the shortest travel's time are calculated between centers of zones. Wherever the arterials are not passing in the center of zone, the distance from the nearest point on arterial to the center of zones is pointed. Link is made to join nearest point on arterial to center of zone and the time of link is computed and added to time of route on arterial.

RESULTS

In this study and for the 5 zones of Al-Ramadi city, 20 routes are made in order to compute the shortest paths between zones. Figure 8 shows the routes from Sector 1 (Origin) to other sectors (Destinations).

Figure 9 shows the routes from Sector 2 (Origin) to other sectors (Destinations).

Figure 10 shows the routes from Sector 3 (Origin) to other sectors (Destinations).

Figure 11 shows the routes from Sector 4 (Origin) to other sectors (Destinations).

Figure 12 shows the routes from Sector 5 (Origin) to other sectors (Destinations).

Table 6 shows the minimum travel's time (running time) between the 5 zones in Al-Ramadi city.

The travel's time from sector 1 (origin) to sector 2 (destination) is 224 sec, while the travel's time from sector 2 (origin) to sector 1 (destination) is 200 second. The difference in time is due to the direction of route (the ability of GIS to generate detailed directions along the route).

Table 7 shows the percentage of saving time for the network routes which determined by using the network analysis of GIS software. Hence, the saving in time will improve the network level of service which in turn minimize the fuel consumption, pollution, noise rate and also improve the performance period of pavement structure.

CONCLUSIONS

Through using the GIS Network Analysis software, this study showing that the travel time can be reduced to the one half if some paths (routes) are used by the road users. Hence, the network level of service can be improved that mean fuel consumption, pollution, and noise can be reduced in addition to improve the performance period of pavement structure due to reduce the congestion which in turn reduce the time of vehicle standing on pavement which has a bad action if comparing with moving vehicle.

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Table (1) Land use percentage of Al- Ramadi City

Land use	Area by Hectare	Percentage (%)
Residential	1588.0	33.4
Educational	390.0	8.2
Commercial	382.0	8.0
Recreational	121.0	2.5
Industrial	194.0	4.1
Green areas and Agriculture	980.0	20.6
Train station	380.0	8.0
Public facilities	268.0	5.6
Health centers	25.0	0.5
Water surfaces	120.0	2.5
Religious	16.0	0.3
Cemetery	200.0	4.2
Oil storage	85.0	1.8
Total	4749.0	100.0

Table (2) Average yearly growth and increase in population in Al-Ramadi City (Iraqi Censuses)

Year	Population	Increase in population capita	% Increase in population
1947	9919	-	-
1957	17826	7907	79.7
1965	29265	11439	64
1977	91909	62644	214
1987	124331	32422	35.3
1997	163206	38875	31.3
2009	230500	67294	41.2

Table (3) O-D Matrix Of Trips Of Al-Ramadi City, Study Of Engineering Consultancy Bureau, (Engineering College, Al Mustansyriah University) Masterplan Of The City Of Al-Ramadi Stage 1 Report -Field Survey Report, 2009.

Sector	1	2	3	4	5
1	11642	16323	434	213	2234
2	3856	23982	626	242	1412
3	238	1186	1457	329	313
4	1386	4456	229	4014	729
5	776	1732	669	786	2504

Table (4) Major Arterials in Al-Ramadi City, study of Engineering Consultancy Bureau, (Engineering College, Al Mustansyriah University) MASTERPLAN OF The City of Al-Ramadi Stage 1 Report -Field Survey Report, 2009.

Arterial name	Length km	Width of Road including sidewalk and Median (m)
Twenty Street	1.5	20.7
Al-Maarid Street	1.6	28.0
17 Tammoz Street	2.5	29.0
Adnan Street	8.5	25.0
Alwaleed Street	2.5	27.0
Almustauda` Street	1.15	28.0
Isqan Street	1.00	20.0
Glass Factory Street	4.6	29.0
Al-Siramik Street	3.15	27.0
Al-Malab Street	2.1	30.0
8 Shbat Street	2.96	28.0

Table (5) Volume of traffic in the morning peak, study of Engineering Consultancy Bureau, (Engineering College, Al Mustansyriah University) MASTERPLAN OF The City of Al-Ramadi Stage 1 Report -Field Survey Report, 2009.

Arterial name	Volume of traffic	Directional Distribution Factor (DDF)(%)
Twenty Street	1450	85%
Al-Maarid Street	1211	80%
17 Tammoz Street	1503	60%
Adnan Street	1236	60%
Alwaleed Street	1383	55%
Almustauda` Street	1434	65%
Isqan Street	465	70%
Glass Factory Street	1768	60%
Al-Siramik Street	1200	60%
Al-Malab Street	1370	60%
8 Shbat Street	1385	60%

Table (6) Minimum travel's time (running time) between the 5 zones in Al- Ramadi city

Sector	1	2	3	4	5
1		224 sec	923 sec	489 sec	838 sec
2	200 sec		832 sec	399 sec	847 sec
3	780 sec	696 sec		410 sec	212 sec
4	467 sec	383 sec	453 sec		467 sec
5	695 sec	709 sec	211 sec	424 sec	

Table (7) Percentage (%) of saving time for the selected network routes by GIS Network Analysis Software.

Sector	1	2	3	4	5
1		47	1.8	49	12
2	14.5		1.89	53.8	1.7
3	3.5	1.97		0	0
4	43	48	53		52
5	15	1.9	0	0	

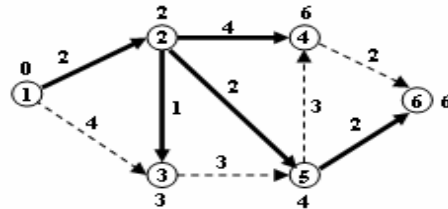


Figure (1) An example of Dijkstra's algorithm (Orlin 2003).



Figure (2) Map of Al-Iraq

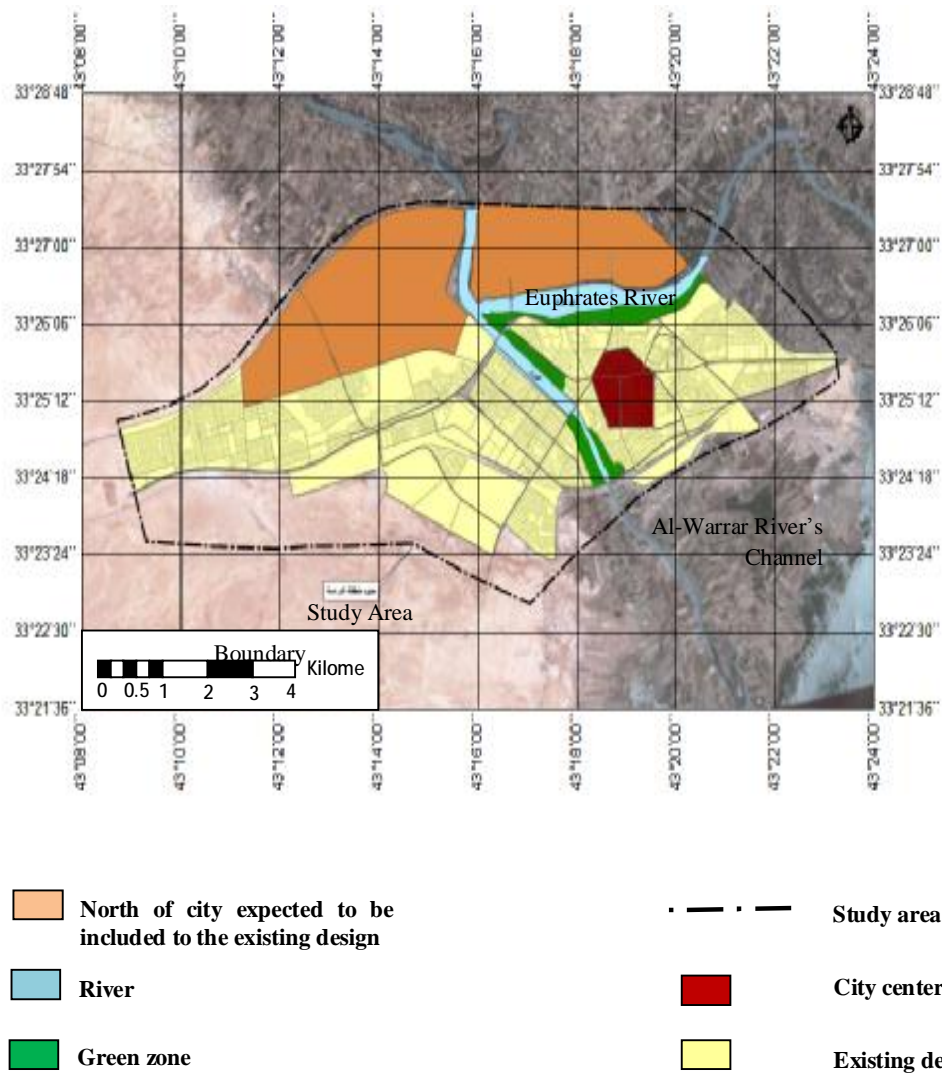


Figure (3): Division of Al-Ramadi and the nearest areas (Ministry of Municipalities and public works (General Directorate of Physical Planning)).

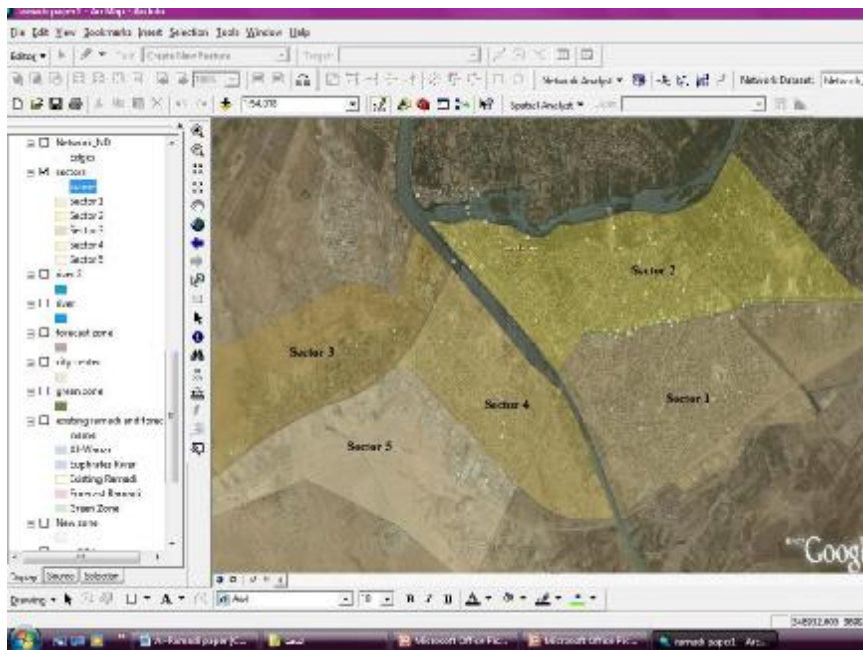


Figure (4) Zones of Al-Ramadi city

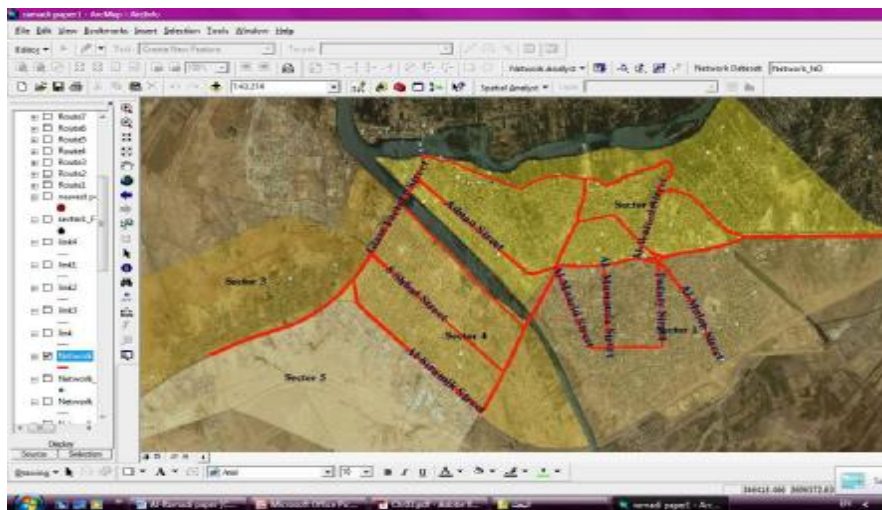


Figure (5) Major arterials in Al-Ramadi City

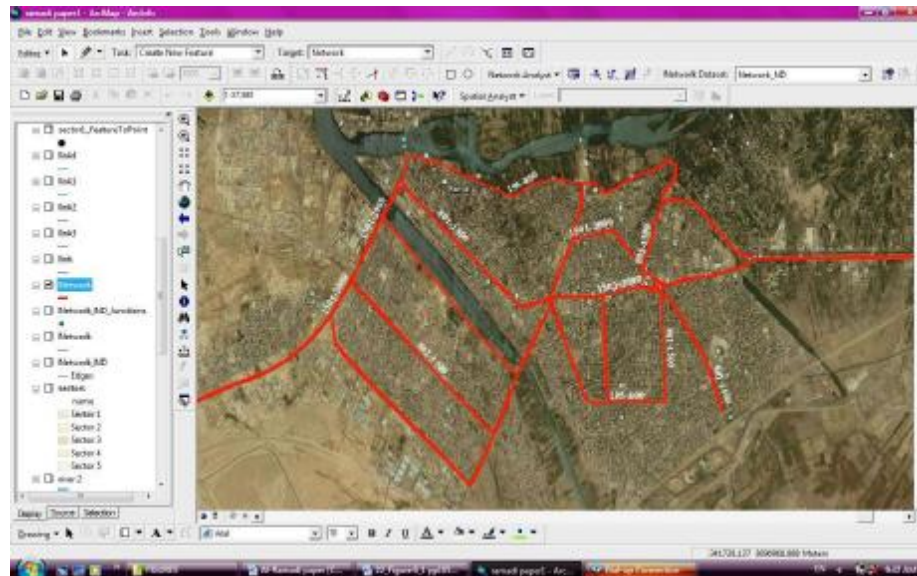


Figure (6): Volume of traffic in the morning peak.

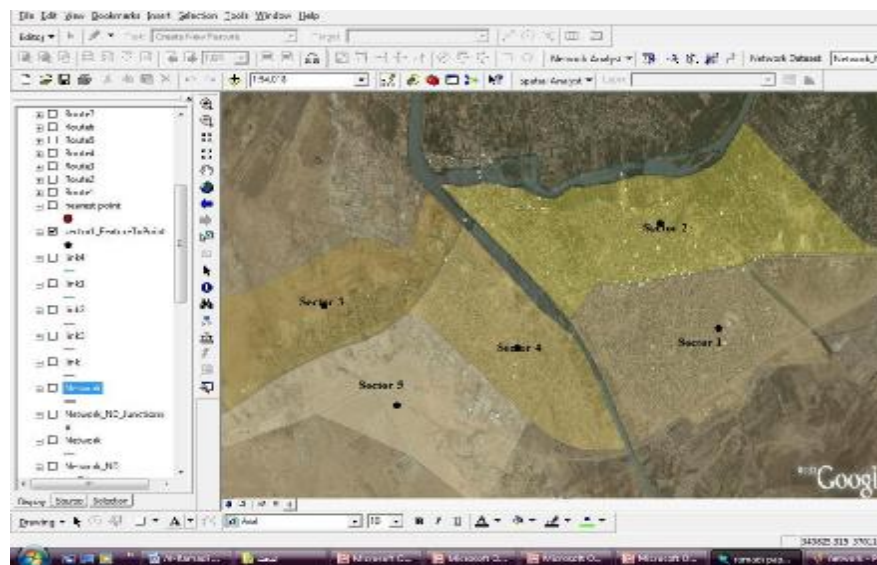


Figure (7) Centered of zones in Al-Ramadi city.

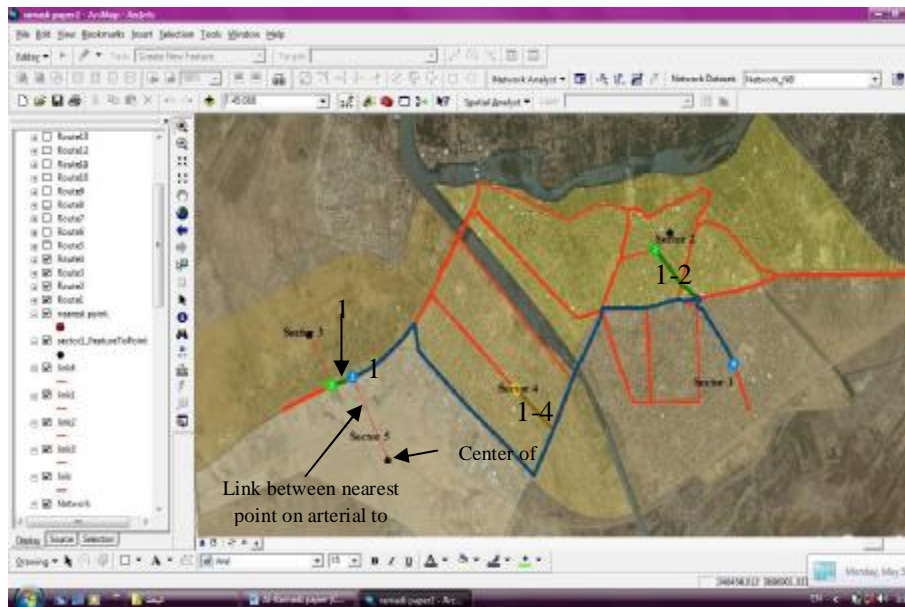


Figure (8) Routes from Sector 1 (Origin) to other sectors (Destinations).

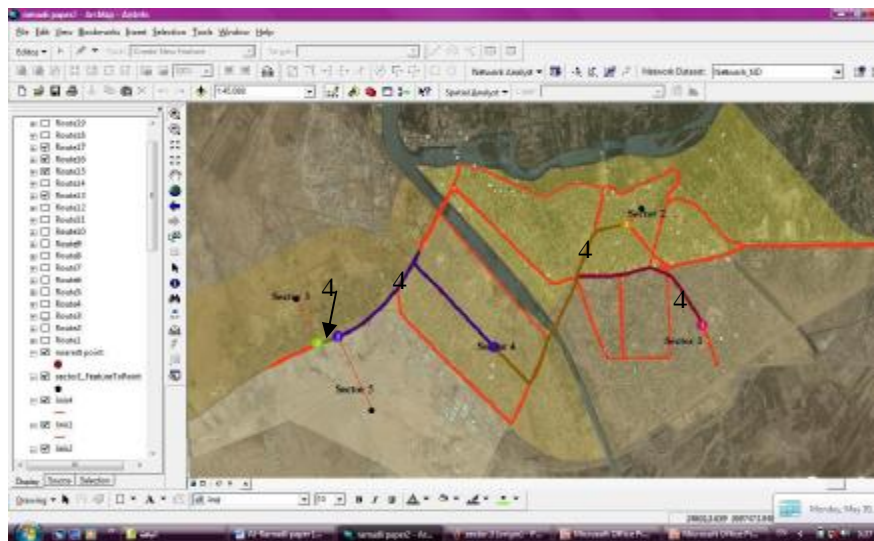


Figure (9) Routes from Sector 2 (Origin) to other sectors (Destinations).

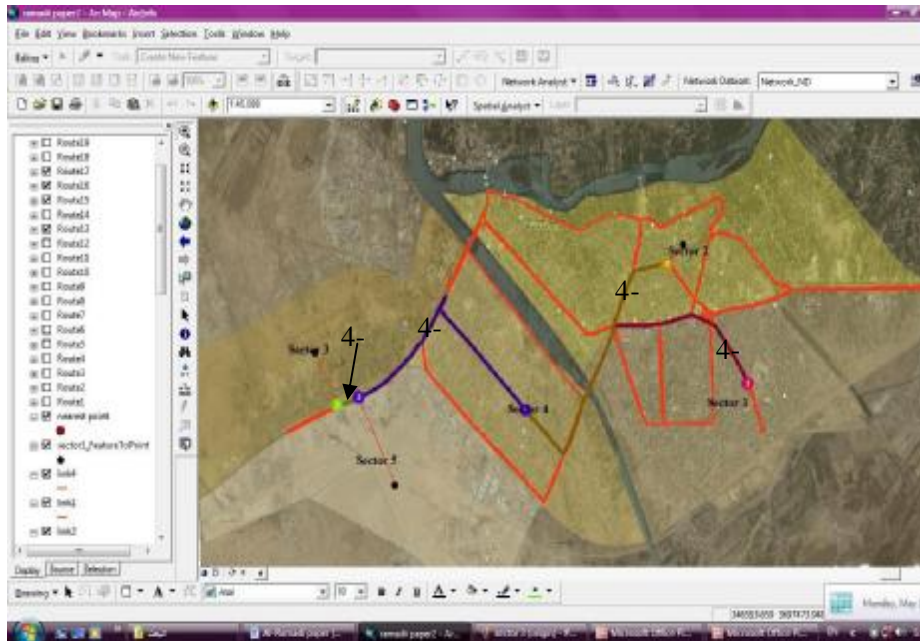


Figure (10): Routes from Sector 3 (Origin) to other sectors (Destinations).

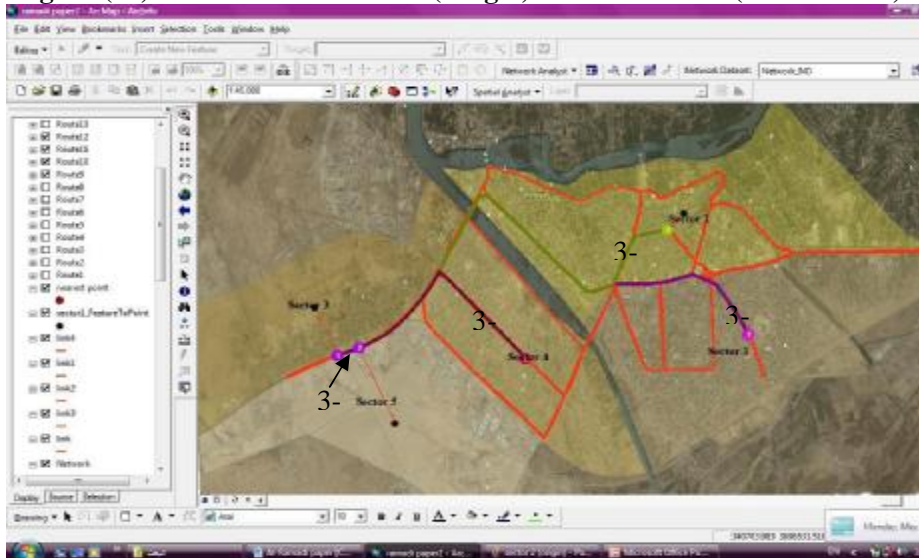


Figure 11: Routes from Sector 4 (Origin) to other sectors (Destinations).

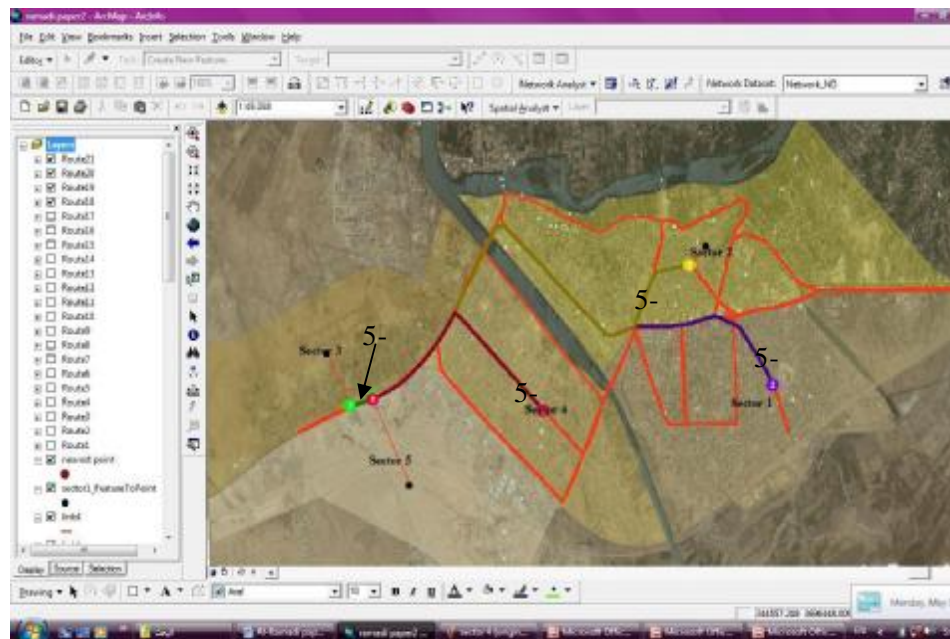


Figure (12): Routes from Sector 5 (Origin) to other sectors (Destinations).