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Evaluating the Road network in Kut City by using TransCAD and GIS Techniques

Oulla F. Aboodi & Dr. Gofran J. Qasim

Abstract

Al-Kut city, like many other Iraqi cities, has a thorough research literature in proposals for traffic control or transportation planning that consider the growth of the population, employment, and car ownership each year, all of which have an effect on daily activities. day after day. Utilizing programs likes (TransCAD, GIS), the network is utilized to evaluate the patterns of current traffic flow. and gather various types of data, including for the work of the extensive road network, field surveys are performed. The evaluation's findings indicated that the majority of the city's roads had a level of service type (A), with the exception of Al-Naseej, Baghdad-Al-Kut, Al-Tarabiya, and Al-Harah streets, which have service-level types (F) at which the ratio of vehicles to road capacity (v/c) is above one. On that premise, it was planned to build new roads to shift the course of external - external trips, as well as add lanes, to alleviate the congestion that had developed in the problem area.

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1. Introduction

Transportation serves as a means of transferring products and information as well as supporting societal economic advancements (Garber, & Hoel , 2018). For human endeavors like trade, recreation, and defense as well as enabling travel for employment, research, and personal fulfillment (Qasim, Ziboon, & Falih, 2018). Wasit, which offers strong connections and excellent connections between Kut and the other District Centers, Alkaremya & Aljehad, AL Karama, Almarkaz & AL Kafaat, and Damook AL Khajeya, which lack adequate local services, is the main focus of travel patterns in the central section of Kut. Traditionally, a four-step sequential model is used to forecast travel demand (trip generation, trip distribution, mode choice, and traffic assignment). Geospatial and statistical models serve as the foundation for creating a thorough understanding of goods transport (Alshurafa, 2020). In several applications, Air quality effect analysis, benefit estimation, traffic safety models, and model selection analysis are all included, the findings of a transportation research are utilized to help predict travel demand (ABEDALI, & QASIM, 2017). There is a lot of literature dealing with urban transportation all throughout the world. The following are some of these studies: (Yousif, 2018). Planning for urban transportation involves determining the shortest route, taking into account both the present state of transit infrastructure as well as anticipated future growth and development. Planning comes in two forms. The first is a short-term plan that focuses on initiatives that can be put into action within 1-3 years with the intention of improving public utility management. The second is the long-term plan, which seeks to enhance transportation over a lengthy period of time and is intended to be executed for more than 20 years (Hoel & Garber, 2010). . Examine and evaluate the various survey techniques applied in research projects where data is gathered to provide insight into the operations of urban road transportation. Recognizing how road transportation works The essay contained numerous different types of surveys (commodity flow surveys, intersection surveys, GPS), which are vital for analyzing urban road efficiency and effect as well as how to best promote sustainability economically, socially, and (Allen, Browne, Woodburn, & Leonardi, 2012). This study aims to evaluate the capacity of the road network of the city of Kut using GIS and TransCAD techniques.

2. Case study

The study area is Al-Kut city the center of Wasit Governorate. Al-Kut is a city in AL- Iraq. Southeast of Baghdad, on the banks of the Tigris River, is where it is situated. The boundaries of Al-Kut City are (32°27'00 to 32°34'00) N and (45°46'00 to 45°53'20) E. It is area about (17,153 square kilometers. It is regarded as Waist Governorate's administrative center. Waist largest city in terms of both population and area. Early in the nineteenth century, Al-Kut was established. From the northwest to the south-east, the Tigris River flows into the city. It is located along the Tigris River, which borders the city's core on three sides and divides into two directions only to the city's north. according to Figure 1. Al-Kut city is situated in the middle of the major cities that surround it, with an average the distance of about 220 km from Amara, Al-Nasiriya to the south, Al-Diwaniyah, as well as Hellah to the west. As for its geographic location as well as its relationship with the surrounding regions, it is connected to Baghdad because it is about 180 km away from it. This makes Al-Kut city a variety of regional relations. The city's location on the road system between Baghdad and the southern governorates, particularly the Basra port, gave it a unique standing in economic exchange, encouraged commercial mobility within it, and contributed to the city's expansion in terms of both industry and commerce. Its closeness to the most significant Iranian border crossings specifically, the city of Badra, that is 70 kilometers to the north of Al- Kut adds another benefit, giving the governorate of Al- Kut and Wasit a crucial and strategic location.

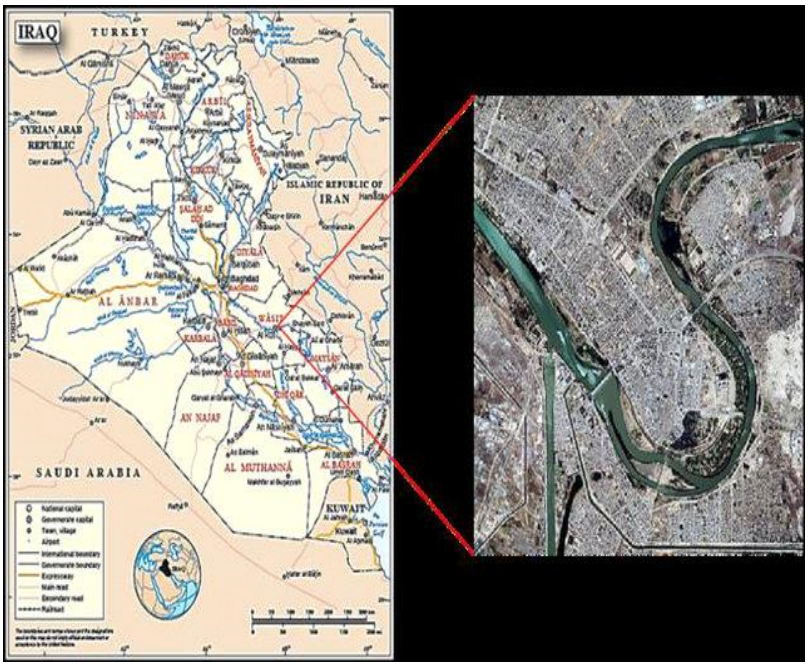

Figure 1. Al-Kut city is located in Iraq as seen on the map (Mohammed, Ziboon, Kamal, & Alfaraj, 2018).

3. Aim and Methodology of Research

This study's objective is to evaluate the road network's capacity in the city of Kut utilizing geographic information systems and the transportation planning process. It also explores a list of network problems and suggests solutions. Primary goals are to: (i) Collect data on the province's transportation system to aid decision-makers' work on the establishment of a road network, (ii) Using suitable transportation planning software, such as ARC GIS, to build a geospatial database for Kut City's road system, and (iii) Preparing a vehicle traffic database that includes the following: (a) Surveying the movement of vehicles during peak hours represented by two periods from (7:30 to 9:30 am) and (1:30 to 3:30 pm) for weekdays (Monday-Tuesday and Wednesday) and (b)collect intersection data, which was done during the morning rush hour (7:30-8:30 a.m.).

4. Data Collection

The goal of the data collection phase is to collect all the information required to show the traffic flow situation at the research site. According to a significant study, the following are the fundamental procedures for data gathering and implementation: A variety of data types from various sources are obtained in order to support the study's objectives. As follows:

1- Official Data
   While the Municipality Directorate provides maps for kut city, the Traffic Police Directorate of Kut provides data on the number of cars and their classification by kind. These statistics came from numerous organizations.
2- Manual Data
   The study area's traffic characteristics are revealed through the hand count method employed to collect traffic information. As illustrated in figure 2, traffic volume studies are conducted to ascertain the quantity, movements, and kind of road vehicles in the well-known site.

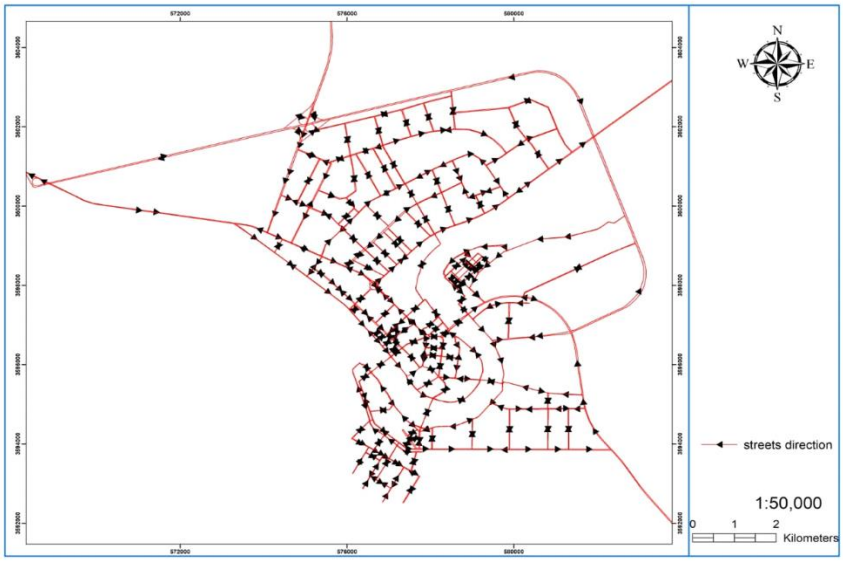

Figure 2. Manual count sites for all network links

5. Software used for data analysis

Two software programs were utilized to study and assess the performance of the chosen network's traffic using the site's abstracted and processed traffic and geometric data as inputs. Both TRANSCAD 4.5 and ARCGIS 10.8 have been employed.

5.1 ArcGIS 10.8

ArcGIS offers capabilities for spatial reasoning and contextual mapping examine data and communicate insights depending on the place. With ArcGIS, you can make, utilize, and share maps that are connected to any device. In this study, the road network was defined and the study area was divided into traffic segments using the ARC GIS tool. The shape file was exported and utilized subsequently in the Trans CAD application to create a database that would be used for the analysis process.

5.2 Trans CAD (4.5)

The only piece of software that completely combines GIS with features for demand modeling and logistics is Trans CAD (Almasri, & Al-Jazzar, 2013)

Trans CAD is hence

- Transportation Planning and Travel Demand Modeling
- Network Analysis
- Transit Analysis
- Vehicle Routing and Logistics
- Traffic Assignment

This study made use of the stochastic user equilibrium traffic assignment model found in TransCAD Software 4.5. The road network file and the origin-destination (O-D) matrix file are the two key inputs required by this approach. First, as in this study, the road network dataset from GIS program can be loaded. This file contains information about the road network, including Identify Data (ID), length, width, number of lanes, flow direction, capacity, flow, and speed for each connection. The ID and x-y coordinates of each node, which indicate an intersection, are also provided. The easiest method is to utilize the O-D matrix to express the trip demand throughout the defined sectors of Sectors 1, 2, 3, and 4. Trans CAD is unable to operate in the absence of such a matrix, in addition to starting and finishing excursions at a few particular sites inside the city network. This has led to the usage of centroid nodes as a

solution to the problem. A sector's centroid point indicates where the sector's geographic center is. A new set of links called centroid connectors is constructed in order to connect these centroids to the road network (Al-Duhaidahawi, et al., 2020).

6. Traffic Analysis zone of Al-Kut city

Before the technical process of travel forecasting can be carried out, the research region needs to be divided into several Traffic Analysis Zones (TAZ) that act as the foundation for travel patterns inside, into, and outside of the urban area. Zones can be joined to form districts, which are important units (O'Flaherty, 1986).

The city of Al-Kut is divided into four sectors. for the gathering and monitoring of data. The following criteria are used to choose these zones (Garber & Hoel, 2009):

- Social and economic features should be uniformity.
- It is necessary to reduce Interzonal travel.
- Physical, political, and historical cordons must be used where it is possible. based on how number zones divided Kut city into 4 zones, including the zone illustrated in Figure 3, the type of matrix for (O - D) is (4*4).

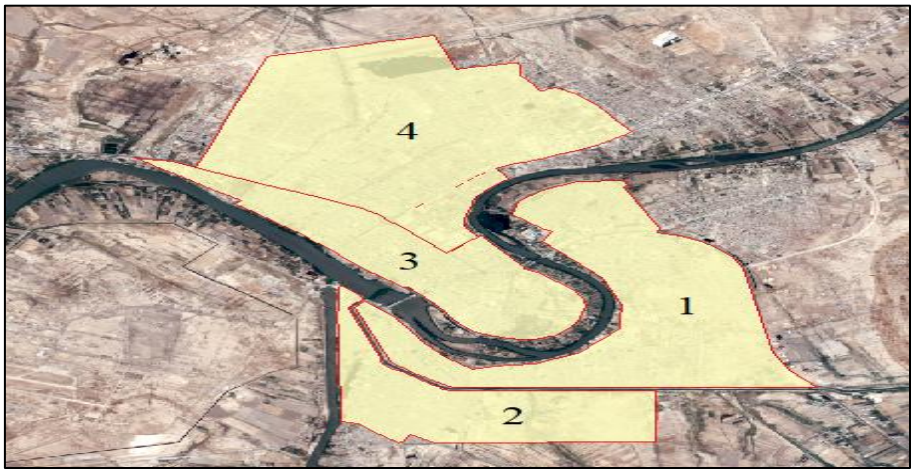

Figure 3. Zones of Al-Kut city

7. Creating the Road Network Shape Files

The aerial picture was used to create shape files of the road network, Table 1, Figure 4, which summarizes the collected data, in order to carry out the traffic assignment analysis. Shape files of a road network were created using the Arc Catalog tool, which contains A polyline feature was used to illustrate the layer of links and bridges. These shape files, which are represented by 840 links, and the major, collector, and minor roads, bridges, and overpasses of Al-Kut city in Figure 5, have 840 links in total. The intersection layers and their 793 nodes are shown as point features in Figure 6.

Table 1. The details of satellite images

Product Type	Standard	Product Option	Natural Color
Bit Depth	16	File Formal	IMAGINE Image
Tiling	Map Projection	Map Projection	UTM
Delivery Method	DVD	UTM Zone	38N
License Type	Single	Datum	WGS84

*Quick Bird Standard illustration for the 18 largest cities in Iraq is 4-band pansharpened, radiometrically corrected, sensor corrected, and map projected with a resolution of 0.5 meters. The acquisition data ** is for 2018 or newer. Cloud coverage for new imagery could reach 20%

Figure 4. Satellite photo of Al-Kut City (2018)

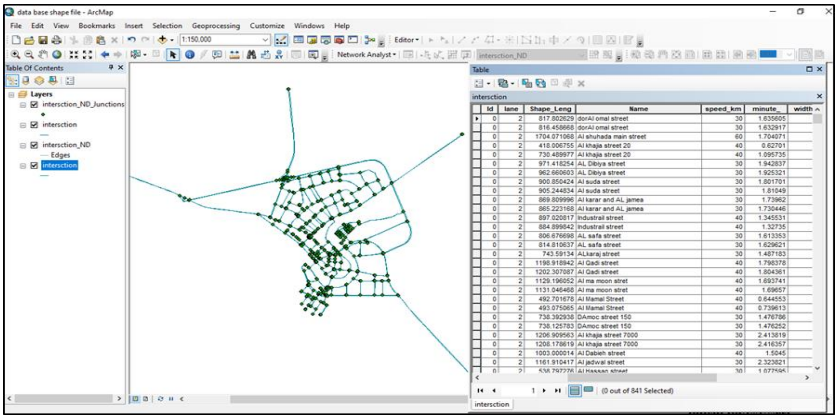

Figure 5. Network of Al-Kut Road's Layered Links

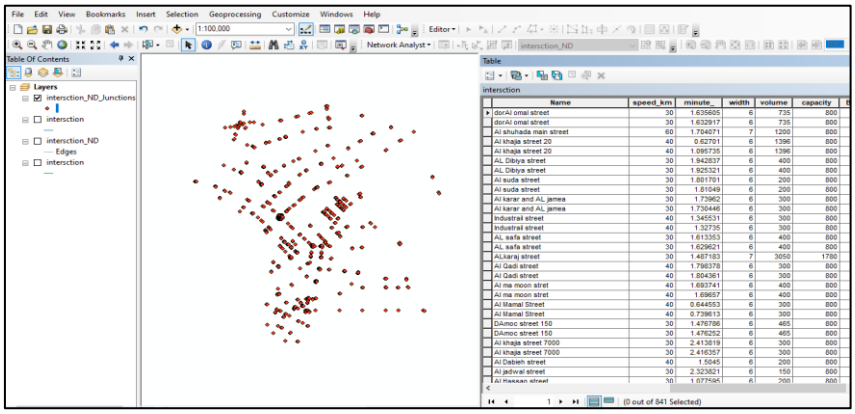

Figure 6. Layer of Al-Kut Road Network Nodes and Intersections

8. Preparing the network's road data base

8.1 Data Base of Links Shape File

Kut road system database was produced using GIS, while the others were gathered through measurement or observation. Most of the attribute data was gathered in three categories. The first set of data were description attributes, which describe roads (for example, length, width, number of lanes, speed limit, and capacity), and the second set of data were cost attributes, which are crucial for road analysis in order to determine the best location for a route and to calculate the cost of time (drive time) in minutes. Third place went to the restriction attributes, which are equally significant when combined with the cost attributes. One-way and no-entry roads are among the restriction values contained in this attribute data, as shown in table 2

Table 2. The component of the data set for links attributes

ID	Link Id	One Way	Name	Length (m)	Speed (km/hr)	Link width (m)	Capacity (vph)	Time
1	4	2	Al nassige street	187.297101	80	15	4570	0.374594
2	5	3	Al nassige street	225.361475	80	15	4570	0.450723
3	10	3	Al nassige street	479.881692	80	11	4570	0.959763
4	12	2	Haidari street	312.609415	40	6	800	0.468914
5	13	2	Haidari street	20.92514	40	6	800	0.031388
6	23	2	Haidari street	309.617956	40	6	800	0.464427
7	24	2	Haidari street	18.955672	40	6	800	0.028434
8	25	2	Haidari street	788.406278	40	6	800	1.182609
9	26	3	Kut Bagdad Street	8.646267	80	15	3430	0.006485
10	27	3	Kut Bagdad Street	104.006813	80	15	3430	0.078005
11	28	3	Kut Bagdad Street	48.339996	80	15	3430	0.036255
12	37	3	Kut Bagdad Street	29.26805	80	15	4570	0.021951
13	38	2	Al tarbia street	634.657847	30	6	2430	1.269316
14	40	2	Sahat aleamil street	294.817533	30	6	1000	0.589635
15	41	2	Sahat aleamil street	408.650887	30	6	1000	0.817302

8.2 Data Base of Nodes Shape File

The number of nodes and their coordinates in the node layer database were included. These attributes, which were added to the attributed table of the nodes layer, are demonstrated in Table 3 by way of an example. For the road network in the study area, the node property is necessary for network analysis and traffic assignment.

Table 3. Part of Nodes and Intersections Attributes

ID	(E) Coordinate (m)	(N) Coordinate (m)
1	562998	3602993
2	568270	3600862
3	568573	3600706
4	568858	3600562
5	568884	3600569
6	573290	3599556
7	573304	3599573
8	573333	3599551
9	573333	3599551
10	574066	3599349
11	574087	3599360
12	574088	3599361
13	574107	3599330
14	574256	3598842
15	574270	3598831

9. Traffic volume

The field traffic counting began on regular days (Sunday, Monday, and Tuesday), and data was gathered from 7:00 AM to 9:00 AM. The data were organized according to the relationship between vehicle class and driving direction. When the traffic was counted, five different types of vehicles were categorized: private cars, buses (which include all vehicles with a capacity of 24 people), minibus, trucks (any vehicle with more than two axles), and finally, bikes and motorbikes, as indicated in Table 4. Table 5 and 6 show the study area's peak-hour traffic volumes for main roads and minor roads.

Table 4: Transportation numbers and percentages in the study area

Investigated Street	Dir.	Passenger Car	%	BUS	%	Mini Bus	%	Truck	%	Motor cycle	%
Al-Naseej Street	AB*	2840	77.5	42	1.1	408	11.1	164	4.5	211	5.8
	BA*	2912	78.7	40	1.1	445	12.1	93	2.5	210	5.7
AL-Haidariya Street	AB	1703	95	21	0.1	12	0.67	0	0	75	7.1
	BA	993	93.4	2	0.2	21	2	0	0	48	4.5
AL-Horh Street	AB	869	95.1	3	0.3	12	1.3	0	0	29	3.2
	BA	668	93.2	3	0.42	23	3.2	0	0	23	3.2
Al-Zahraa commercial Street	AB	687	94.2	3	0.41	18	2.5	5	0.7	16	2.2
	BA	545	93.1	1	0.2	9	1.6	3	0.52	22	3.8
Madkhal Al-Kut Street	AB	2984	86.5	40	1.2	250	7.4	100	3	75	2.2
	BA	2340	85	30	1.1	250	9.1	100	3.6	34	1.2
Dawr Al-Dubaat Street	AB	104	64	2	1.2	13	8	0	0	44	27
	BA	104	66.2	2	1.3	13	8.3	0	0	38	24.2
Al-Tarbia street	AB	1678	94	5	0.3	52	3	0	0	50	2.8
	BA	1218	89.3	8	0.6	49	3.6	0	0	85	6.3
Kurnish Al Sadd Street	AB	1008	86	2	0.2	12	1.1	0	0	154	13.1
	BA	855	87.1	1	0.1	25	2.5	0	0	100	10.2
Sahat Al-Eamil Street	AB	185	84.1	0	0	10	4.5	0	0	25	11.4
	BA	160	88.9	0	0	8	4.4	0	0	12	6.7
Street behind the university	AB	1519	93	3	0.2	100	6.1	0	0	17	1.03
	BA	1326	92.6	2	0.14	86	6	0	0	17	1.2
Al-Emam Ali Street	AB	548	79.2	5	0.7	18	2.6	1	0.14	120	17.3
	BA	380	74.3	2	0.4	25	4.9	1	0.2	103	

*AB & BA = trips in direction

Table 5: The traffic volumes (main roads) of the study area during peak hour

Street Code	Street Name	M. Dir.*	Traffic Volume veh/h	T.V Veh/max 15min	M. Dir.*	Traffic Volume	T.V Veh/max 15min
1	Al-Naseej Street	AB	3665	1066	BA	3700	**980**
2	AL-Haidariya Street	AB	1792	573	BA	1064	**376**
3	AL-Horh Street	AB	913	382	BA	717	**290**
4	Al-Zahraa commercial Street	AB	729	323	BA	580	**235**
5	Street behind the university	AB	1639	545	BA	1431	**502**
6	**Madkhal Al-Kut Street**	**AB**	**2934**	**894**	**BA**	**2340**	**735**

*Movement Direction

Table 6: The traffic volumes (minor roads) of the study area during peak hour

Street Code	Street Name	M. Dir.	Traffic Volume veh/h	T.V Veh/max 15min	M.Dir.*	Traffic Volume	T.V Veh/max 15min
1	Al-Tarbia street	AB	1678	630	BA	1218	460
2	Kurnish Al Sadd Street	AB	1008	377	BA	855	334
3	Sahat Al-Eamil Street	AB	185	63	BA	160	58
4	Al-Emam Ali Street	AB	584	217	BA	380	180

10. Traffic Assignment execution

The traffic assignment process is made modest by the Trans CAD program version 4.5, which creates the OD matrix and network files with the necessary information. For each assignment, the Trans CAD Stochastic User Equilibrium and System Optimum models are used, with a default of 20 iterations. Each assignment ends with export of the result volumes for each link to the geographic model file. As illustrated in Table 7, the settings for the System Optimum and Stochastic User Equilibrium methods are chosen throughout the assignment process (Haider and Gregoul, 2009):. The trips are then totaled for each link, and the links in the minimal path are awarded trips for each O-D pair. The link's capacity is next compared to the designated trip volume to see if it is overcrowded. If the route is crowded, the trip time is changed to reflect a lengthy travel time on that connection. Travel time fluctuations may result in changes to the shortest route. The process is repeated unless travel demand and supply are balanced. Until this equilibrium is attained, Trips on crowded routes may be diverted to less congested alternatives. Trans CAD automatically produces a new data view and connects the results table to the road network file's attribute table. The level of service (v/c) ratio applied to Kut city model is shown in Table 8. The municipality department used this table to confirm that it was appropriate for the city's roads because the level of service is distributed according to speed and density of traffic.

Table 7. Stochastic User Equilibrium (SUE) and System Optimum Models Settings.

Algorithm Settings	Description	Assignment Method Default Value	
		SUE	System Optimum
Iterations	The maximum number of iterations to be performed	20	20
Convergence	The convergence threshold: If the maximum change in all the link flows is less than this value, the traffic assignment procedure will end even if the maximum number of iterations has not been performed.	0.0100	0.0100
Alpha and Beta	Calibration parameters of the volume-delay function.	$\alpha = 0.15$ $\beta = 4.0$	$\alpha = 0.15$ $\beta = 4.0$

Function	The type of error function used in the Stochastic User Equilibrium assignment	Normal	_
Error	Describes the extent to which the error function employed in the Stochastic User Equilibrium assignment	5.000	_

Table 8. Level of Service LOS (v/c) Ratio used in Al-Kut City Models

Level of Service	(V/C) Ratio
A	0.00-0.50
B	0.51-0.70
C	0.71-0.80
D	0.81-0.90
E	0.91-0.99
F	≥ 1

11. Analyses of network

Performance of the stochastic user equilibrium method SUE assignment, the first of the three convergent algorithms, distributes trips over a network so that no single user may trip more quickly by selecting a different route. It continues to be one of the algorithms that is used most frequently for research and planning in the field of transportation. Its central presumption which is a reasonable assumption is that if there is a faster route, people will take it because it reduces their individual trip times. The outputs of the stochastic user equilibrium assignment model are shown in Figure 7 and Table 9.

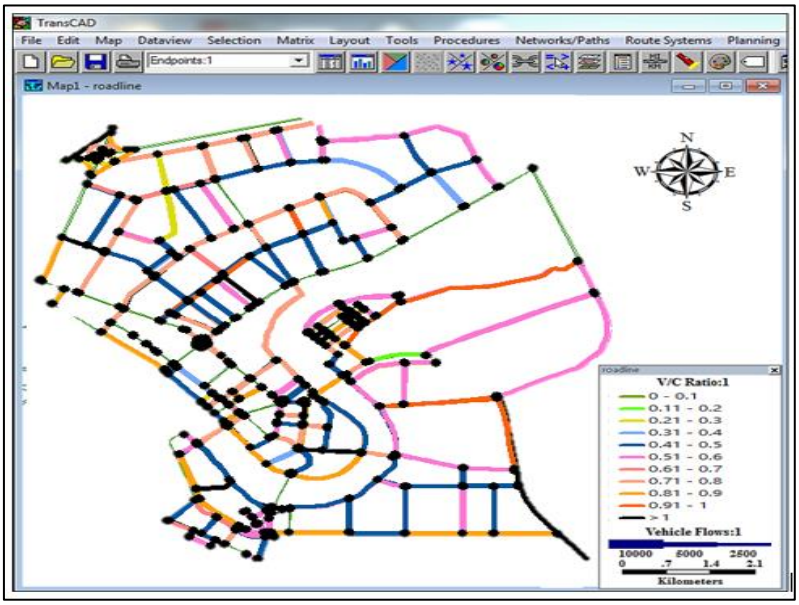

Figure 7. Stochastic User Equilibrium Assignment Model Result

Table 9. Part of Stochastic User Equilibrium Assignment Model Result Table

Id	Shape *	Id	lane	Shape Length	Name	speed_km	T(minute)	width	volume	capacity	Beta	Alpha	V_C	LOS
0	Polyline	0	2	187.297101	Al nassige street	80	0.374594	15	7680	4570	4	0.15	1.68	F
1	Polyline	0	3	225.361475	Al nassige street	80	0.450723	15	7680	4570	4	0.15	1.68	F
2	Polyline	0	3	479.881692	Al nassige street	80	0.959763	11	7680	4570	4	0.15	1.68	F
3	Polyline	0	2	312.609415	Haidari street	40	0.468914	6	300	800	4	0.15	0.38	A
4	Polyline	0	2	20.92514	Haidari street	40	0.031388	6	300	800	4	0.15	0.38	A
5	Polyline	0	2	309.617956	Haidari street	40	0.464427	6	300	800	4	0.15	0.38	A
6	Polyline	0	2	18.955672	Haidari street	40	0.028434	6	300	800	4	0.15	0.38	A
7	Polyline	0	2	788.406278	Haidari street	40	1.182609	6	300	800	4	0.15	0.38	A
8	Polyline	0	3	8.646267	Kut Bagdad Street	80	0.006485	15	6450	3430	4	0.15	1.88	F
9	Polyline	0	3	104.006813	Kut Bagdad Street	80	0.078005	15	7450	3430	4	0.15	2.17	F
10	Polyline	0	3	48.339996	Kut Bagdad Street	80	0.036255	15	7450	3430	4	0.15	2.17	F
11	Polyline	0	3	29.26805	Kut Bagdad Street	80	0.021951	15	7450	4570	4	0.15	1.63	F
12	Polyline	0	3	45.555296	Kut Bagdad Street	80	0.034166	15	7450	3430	4	0.15	2.17	F
13	Polyline	0	2	634.657847	Al tarbia street	30	1.269316	6	3105	2430	4	0.15	1.28	F
14	Polyline	0	2	294.817533	Sahat alsamil street	30	0.589635	6	1000	1600	4	0.15	0.63	B
15	Polyline	0	2	408.650887	Sahat alsamil street	30	0.817302	6	1000	1600	4	0.15	0.63	B

11.1 Performing Stochastic User Equilibrium Method

The v/c ratio is separated into ten classes in figure 7, as can be seen. The majority of the Al-Kut road network's links are colored green and have (v/c) ratios between (0.00-0.50), level A of service. The links in the v/c range between (0.50-0.70) LOS B, which comprises around 18% of all links, are represented by the green and blue colors, such as (22-23-32-33-41-45-107-114-115-273-274-275, etc.). The links in orange reflect the 10% of links from the LOS C range between (0.70-0.80), including The ID for some links in the Al-Kut network are (40-69-91-92-93-99-101-102-194-195-199-208-217-261-277), and there are 4% of links with a v/c ratio between 0.80-0.90, which represents level of service D, and the ID for some links are (43-77-110-112-133-140-141-143-245-246-422-502), and 2% of links with a v/c ratio between (0.90-0.1), which represents LOS E. The city, particularly in the middle where it originally showed in connections for 27%, like the one above, such as (2-3-415-30-34-36-39-46-47-100-123-189-190), clearly displays the range (v/c > 1) represented by the black color. This suggests that these areas are weak. The Al-Kut road network achieved an overall classification of A.

12. Conclusion

From the analysis and assessment of the study area using TransCAD and ArcGIS technologies, Finally, consider the following:

1. The road network in Kut Governorate is classified A according to LOS and V/C, so it is considered to be in good condition. 2- The network suffers from a 27% deterioration of services, which is confined to areas 1 and 4, which represent Al-Naseej Road, which is an important arterial road for the governorate. It consists of 3 lanes due to its connection to the (Baghdad-Kut) road, which is crowded in the morning and evening.

2 - Al-Tarabiya Street, a secondary road, also suffers from LOS F because it connects Al-Naseej Road to Al-Harah Road and is congested in the morning and evening due to a weak network. These locations are depicted in Figure 7 and Table 9 above.

13. Recommendations

Improving network performance through periodic maintenance and regulating traffic situations to maintain network performance in absorbing traffic volume. By analyzing the network, especially Al-Naseej Street and Al-Tarbia Street, which is the road leading from Baghdad to Kut, the Kut Municipality found solutions for the black spots by increasing the number of lanes and increasing the capacity of the road. It has been suggested to adjust the route of external-to-external travels by adding new routes.

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