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Enhanced Road Network to Reduce the Effect of (External – External) Freight Trips on Traffic Flow

Huda Abdulameer Abbas [1*], Hayder Abbas Obaid [1], Ali Abdul Ameer Alwash [1]

[1] *Department of Civil Engineering, College of Engineering, University of Babylon, Babylon, Iraq.*

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Abstract

The transportation system is often described as the lifeblood of modern society. Roads constitute a fundamental part of this system for both passenger and freight transports, a well-functioning freight transportation system is an essential element in any successful economy. Hilla is one of the most densely populated cities in Iraq. The road network in Hilla city is under additional load due to (external - external) trips, especially freight trips by trucks passing through the city's main entrances to cross into neighboring districts and provinces. This is due to the city's strategic location, which connects Baghdad with the southern provinces, making it an important transit route. The objective of this research is to study a proposal for modifying and developing the road network in the city of Hilla by adding new roads to the current network in order to reduce the negative impact of freight trucks passing through the city, especially (external - external) trips, by using Trans CAD and ArcGIS software network analysis. The result of network analysis shows that the suggested roads will reduce the total (travel time and distance) for the same origin and destination points by 9%, and 30%, compared with the current distance and time, respectively, while improving the level of service from D to C at peak hours for freight vehicles.

Keywords: Freight Analysis; LOS, Hilla City Area; Traffic Capacity; ArcGIS Software.

1. Introduction

The transportation system is often described as the lifeblood of modern society. Roads constitute a fundamental part of this system for both passenger and freight transport [1]. In general, although trucks only occupy a small proportion of traffic flow, they have a pronounced impact on the traffic. Hence, it is important to study the impact of trucks to help improve traffic operations. Freight transport has emerged as one of the most critical and dynamic aspects of the transport sector, a well-functioning freight transportation system is an essential element in any successful economy [2]. Flexibility is the major advantage of road freight as compared to other modes; trucks offer the possibility of door-to-door service. Infrastructural conditions often restrict other modes from offering this service [3].

In addition to its beneficial impact Road freight transport is a source of congestion. Freight transports reduce the available capacity for passenger movement. The most severe consequences of the use of roads for freight transport deal with sustainability. This includes economic sustainability, environmental sustainability; and social sustainability [4, 5]. The above restrictions depend on several factors, including transportation infrastructure, customer behavior, and the weight and size of vehicles [6]. Large-sized trucks can block the sight distance of following vehicles, and trucks will obstruct the operations of fast vehicles due to the poor acceleration and maximum speed. In addition, it has been found that trucks have an influence on surrounding vehicles, which makes the driving behaviors of these vehicles change [7].

* Corresponding author: huda.abbas.engh382@student.uobabylon.edu.iq

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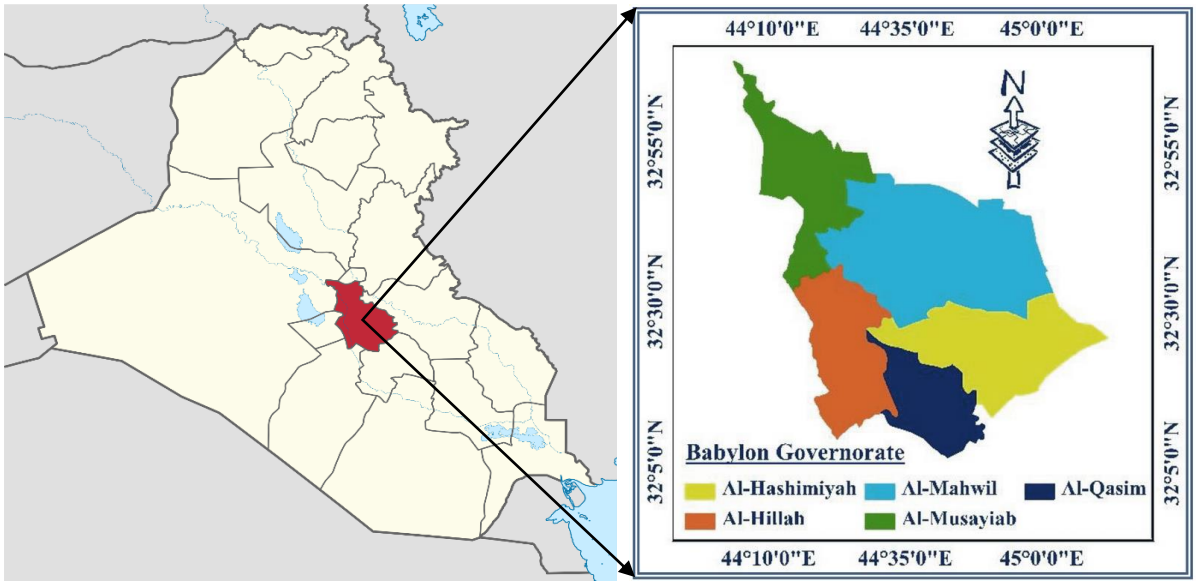
Since roads constitute such a fundamental part of the transportation system, it is essential to invest in new infrastructure as well as maintain and reconstruct existing infrastructure [8]. Hilla is one of the most densely populated cities in Iraq, the commercial growth leads to an increase in the annual growth in the freight traffic volume that affects directly daily activities. While this increased traffic growth is not at all commensurate with the deficiencies in the development of the transport network in the city [9, 10].

The road network in the study area represented by Hilla city (Babylon\Iraq) is under additional load due to (external - external) trips, especially freight trips by trucks passing through the city's main entrances to cross into neighboring districts and provinces. This is due to the city's strategic location, which connects Baghdad with the southern provinces, making it an important transit route. The city of Hilla, like many other Iraqi cities, does not have comprehensive published studies in transportation planning; especially the transportation of goods, taking into account the annual growth in traffic volume and commercial growth that affects daily activities to become a burden that increases day by day. Transportation engineers usually face the problem of how to reproduce information from a field survey. It is important to model truck freight in order to be able to analyze the current situation and suggest future ones.

Various The aim of this study is to investigate a proposal of modifying the Hilla road network located in (Hilla city \ Babylon \ Iraq)) by adding new roads connected with the main roads of the city's entrances to reduce the negative impact of (external - external) freight trips on traffic flow in the internal roads of the city. These trips constitute a higher percentage than the (external _internal) trips, according to the results of a questionnaire survey with freight vehicle drivers at each at each entrance in Hilla City.

2. Study Area

The study area is the city of Hilla, the center of Babylon's Governorate. It is located at 32.29 degrees north of the equator and 44.28 degrees east of Greenwich, about 100 Km south of Baghdad, the capital of Iraq, the city of Hilla is linked to the other administrative units of Babil Governorate through the five main entrances to the city as show in Figure 1.



(a) Location of Babil Governorate in Iraq (b) Babil Governorate map

Figure 1. Study area location

Babylon Governorate is located in central Iraq and occupies the northern part of the middle Euphrates region. It is surrounded on the north by Baghdad governorate, on the south-eastern by Al-Qādisiyyah governorate, on the east by Wasit governorate, on the west by Anbar and Karbala governorates, and on the south by Najaf governorate. The area of Hilla City was about 161 Km^2 and the inhabitants were about 645016 people in 2022, which make up approximately 28.19% of the total inhabitants of Babel Governorate, according to the data of the Babel Statistics Department.

The city of Hilla is characterized by the importance of its geographical location because it is located on the left bank of the Euphrates River within the sedimentary plain area, where it has gained cultural and economic importance as well as its strategic importance in linking the mainland trade routes between the neighbouring provinces.

3. Research Methodology

As Figure 2 shows, the methodology of this study is represented by the following key objectives:

- Building a geographical database for the current and modified road network in Hilla using Arc GIS 10.4 software.

- Perform network analysis and select the best route for (external - external) freight trips from each entrance towered another exit point for both current and modified network and compare it with a current network using the network analysis tool of ArcGIS 10.4 software.
- Determine the level of service for the modified network and compare it with the service level of the current and future network using Trans CAD 4.5 software.

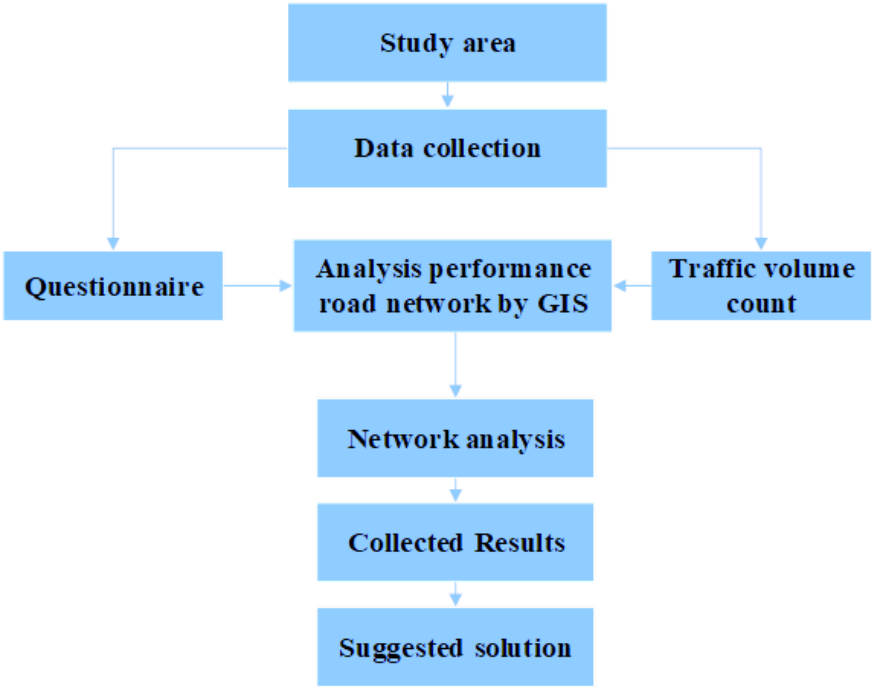


Figure 2. Diagram of work methodology

4. Current Freight Road Network in Hilla City

- The freight network within Hilla city can be classified into two groups according to requirements of highways. Major Arterials with a total length of 77.412 Km and Minor Arterials with a total length of 35,082 Km.
- According to above classification of roads, freight road network with the main entrances to Hilla city were drawn by using the Arc GIS 10.4 software to create a database for current and future analysis as shown in Figure 3.

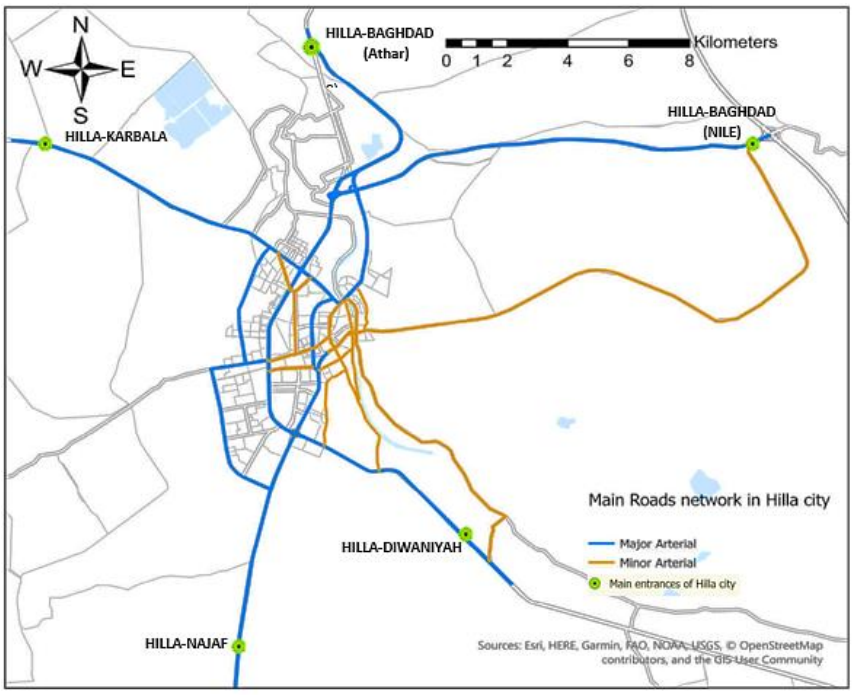


Figure 3. Current Hilla freight road network

5. Characteristics of the New Suggested Roads

Several projects and studies have been developed to enhance the design of public roads [11]. The suggested roads took an oval rotary shape surrounding Hilla city, connecting with the existing network in specific locations and consisting of two freeways and three major arterials with a total length of 27.8 Km and 20.9 Km respectively. Table 1 shows the main characteristics of each suggested road.

Table 1. Characteristics of suggested roads

No.	Location	Type of suggested road	Suggested width*(m)	Suggested speed for freight (Km/hr)	Suggested No. of the lane	Total length (Km)
1	It connects Baghdad Road from the north and passes parallel to the eastern border of the city and then ends with its connection to Najaf Road.	freeway	60	80-90	Three or more lanes in each direction.	18.8
2	It connects Baghdad Road from the north and passes parallel to the Western border of the city and then ends with its connection to Hilla-Karbala Road.	freeway	60	80-90	Three or more lanes in each direction	9
3	It connects Baghdad Road with Hilla-Karbala Road.	Major arterial	60	60-80	three lanes in each direction,	2.6
4	It connects the Hilla - Karbala Road with Tohmaziah Road.	Major arterial	60	60-80	three lanes in each direction,	6.7
5	It connects Tohmaziah Road with Hilla-Najaf Road and ends with its connection to the Hilla-Diwaniyah Road.	Major arterial	60	60-80	three lanes in each direction	11.6

* Total width of the road with its right of way

Suggested roads, and the current road network of Hilla city shown in the Figure 4 by Arc GIS 10.4 software.

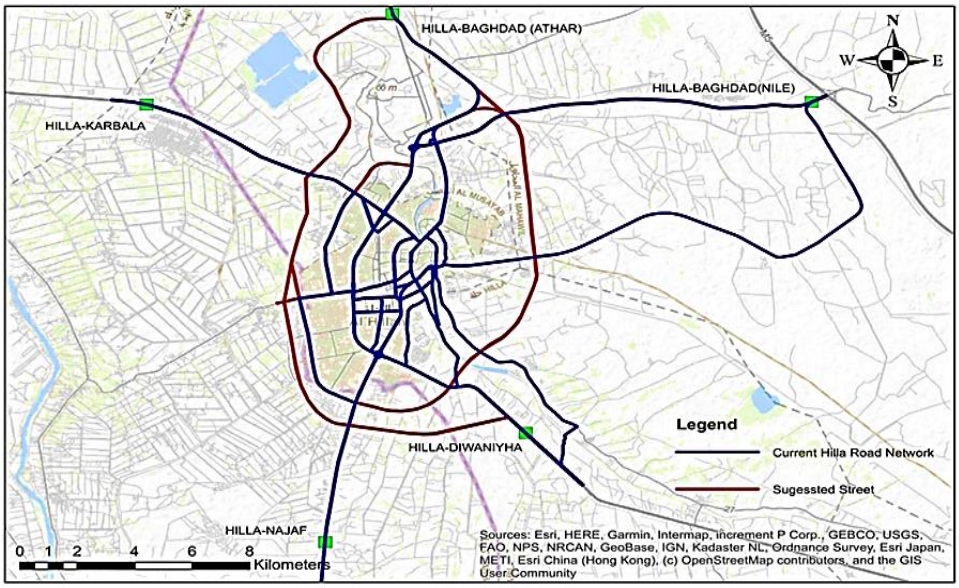


Figure 4. Hilla city modified fright road network

6. Network Analysis for Modified Road Network

The first step is to draw the suggested roads and link them to the existing road network using Arc GIS 10.4 software and prepare the database [12-14]. Three basic types of attribute data, the first type is descriptive data that describes the road link, including (length, width, number of lanes, and speed), the second data is cost attributes and includes travel time in minutes, it is extracted depending on speed, it is very important data in network analysis when finding the best route for vehicles. Finally, the third type of data is called restriction attributes, and it is also important data in network analysis which included the direction of road movement (One way or two-way).

7. Best Route Analysis for (External – External) Freight Trips on Modified Road Network

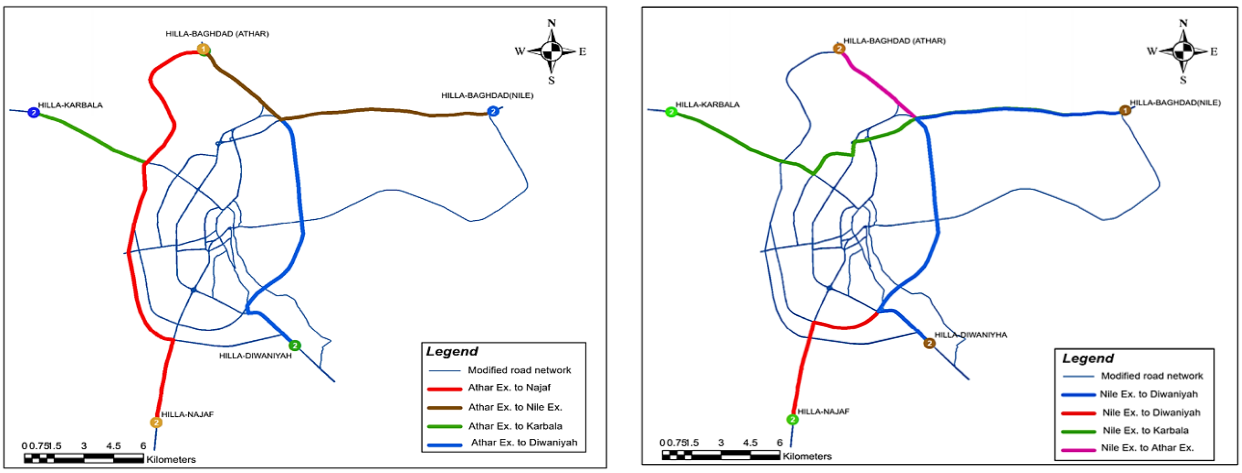
The optimal path is the quickest route if time is an impediment, if the impedance is a distance, the optimum route is the shortest route for a given time of day and date [15-17]. As a result, the optimal route may be defined as the one with the lowest impedance, or the one with the lowest cost, where the impedance is determined by the user.

The result of the best route suggested by the ArcGIS software network analysis tool for both (external-internal) and (external-external) trips on a current road network finds that the largest freight traffic was through the main arterial roads in Hilla City, which suffer from high traffic density [18–20]. A network analysis was conducted for the modified network by the ArcGIS network analysis tool after modifying and updating the characteristics and attribute values of the network file, which contains line and node layers, to check the impact of developing the current network by adding new roads on the process of network analysis and the selection of the best routes for freight movement concerning (external-external) trips.

Depending on the impedance that chosen the fastest and shortest path, the routes that have the most freight traffics volume from each entrance toward other exit point and their main properties by ArcGIS network analysis tool for the modified road network will be explained further.

7.1. Best Route from Nile Entrance to another Exit of Hilla City

Figure 5-a and Table 2, show the routes of the Nile entrance and their main properties, the total sum of the lengths for the proposed route in the modified network, which starts from the Nile entrance toward the other four destinations is equal to 99.89 km while the total time is 80min, these values are lower than those calculated from the current network by 9.19%, 27.28% respectively.



(a) Nile entrances (b) Athar entrances

Figure 5. Best route from Athar and Nile entrance to exterior destination points for the modified road network

Table 2. Properties of Nile entrance- Ex. destination points routes for modified network

Destinations (Modified Network)	Nile entrances		The difference with the current network (%)	
	Distance (Km)	Time(min)	Distance	Time
Nile Ex.	-	-	-	-
Athar Ex.	16.50	12	25	40
Karbala Ex.	25.90	20	4.07	23.07
Najaf Ex.	31.09	26	2.84	23.53
Diwaniyah Ex.	26.40	22	8.97	26.67

7.2. Best Rout from the Athar Entrance to Another Exit of Hilla City

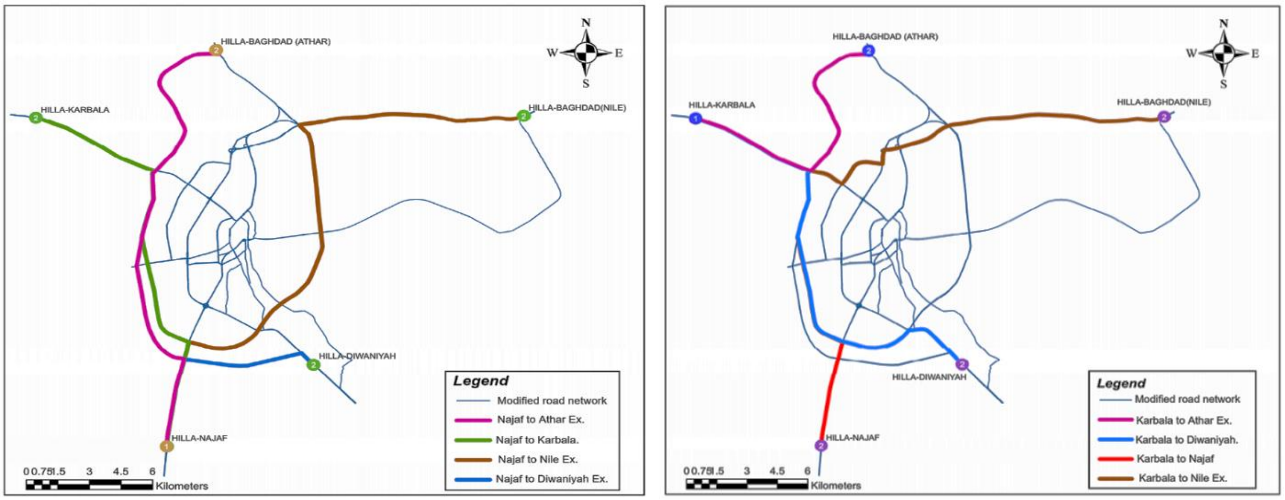
Figure 5-b and Table 3, show the routes of the Athar entrance and their main properties, the total sum of the lengths for the proposed route in the modified network, which starts from the Athar entrance toward the other four destinations is equal to 78.46 Km while the total time is 64 min, these values are lower than those calculated from the current network by 10.84%, 28.89% respectively.

Table 3. Properties of Athar entrance -Ex. destination point route for modified network

Destinations (Modified Network)	Athar entrances		The difference with the current network (%)	
	Distance (Km)	Time (min)	Distance	Time
Nile Ex.	16.56	13	21.15	35
Athar Ex.	-	-	-	-
Karbala Ex.	15.70	12	21.52	36.84
Najaf Ex.	24.91	21	0.36	25
Diwaniyah Ex.	21.29	18		3.23

7.3. Best Rout from Najaf Entrance to Another Exit of Hilla City

Figure 6-a and Table 4, show the best routes for the Najaf entrance and their main properties, the total sum of the lengths for the proposed route in the modified network, which starts from the Najaf entrance toward the other four destinations is equal to 89.94 Km while the total time is 75 min, these values are lower than those calculated from the current network by 2.24%, 25% respectively.



(a) Najaf entrances (b) Karbala entrances

Figure 6. Best route from Najaf and Karbala entrance to exterior destination points for the modified road network

Table 4. Properties of Najaf entrance- Ex. destination points routes for modified network

Destinations (Modified Network)	Najaf entrances		The difference with the current network (%)	
	Distance (Km)	Time (min)	Distance	Time
Nile Ex.	31.10	25	-7.24	16.67
Athar Ex.	24.91	21	0.36	25
Karbala Ex.	22.52	19	9.93	29.63
Najaf Ex.	-	-	-	-
Diwaniyah Ex.	11.41	10	12.23	33.33

The value of the difference in route distance for the modified network with the current network (-7.24) because of the length of the route from Najaf to the Nile exit which resulted from the network analysis before adding the suggested roads passing through the inner-city road where the travelled distance is shorter but at a slower speed due to traffic congestion in the city road.

7.4. Best Rout from Karbala Entrance to Another Exit of Hilla City

Figure 6-b and Table 5, show the best routes for Karbala entrance and their main properties respectively. The total sum of lengths for the proposed route in the modified network, which starts from the Karbala entrance toward the other four destinations is equal to 85.03 Km while the total time is 69 min, these values are lower than those calculated from the current network by 10.50%, 28.87% respectively.

Table 5. Properties of Karbala entrance- Ex. destination points routes for modified network

Destinations (Modified Network)	Karbala entrances		The difference with the current network (%)	
	Distance (Km)	Time(min)	Distance	Time
Nile Ex.	16.56	13	21.15	46.6
Athar Ex.	-	-	-	-
Karbala Ex.	15.70	12	21.52	46.9
Najaf Ex.	24.91	21	0.36	35.7
Diwaniyah Ex.	21.29	18	3.23	36.8

7.5. Best Rout from Diwaniyah Entrance to Another Exit of Hilla City

Figure 7 and Table 6, show the best routes for the Diwaniyah entrance and their main properties. The total sum of the lengths for the proposed route in the modified network, which starts from the Diwaniyah entrance toward the other four destinations is equal to 80.04 km while the total time is 68 min, these values are lower than those calculated from the current network by 11.26%, 29.89% respectively.

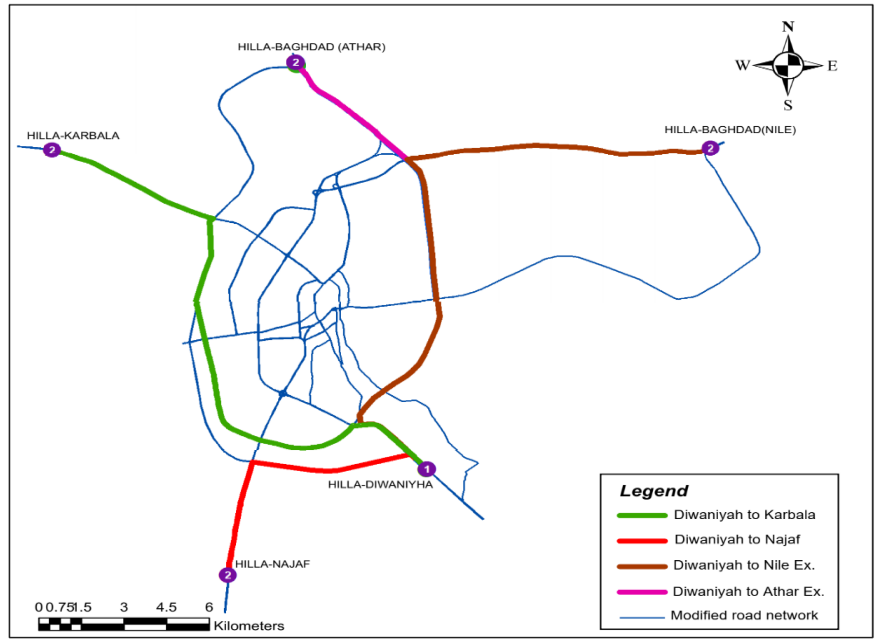


Figure 7. Best route from Diwaniyah entrance to exterior destination points for the modified road network

Table 6. Properties of Diwaniyah entrance- Ex. destination points routes for modified network

Destinations (Modified Network)	Diwaniyah entrances		The difference with the current network (%)	
	Distance (Km)	Time(min)	Distance	Time
Nile Ex.	26.43	22	17.40	35.29
Athar Ex.	21.29	18	3.23	21.74
Karbala Ex.	20.91	18	9.08	28
Najaf Ex.	11.41	10	13.53	33.33
Diwaniyah Ex.	-	-	-	-

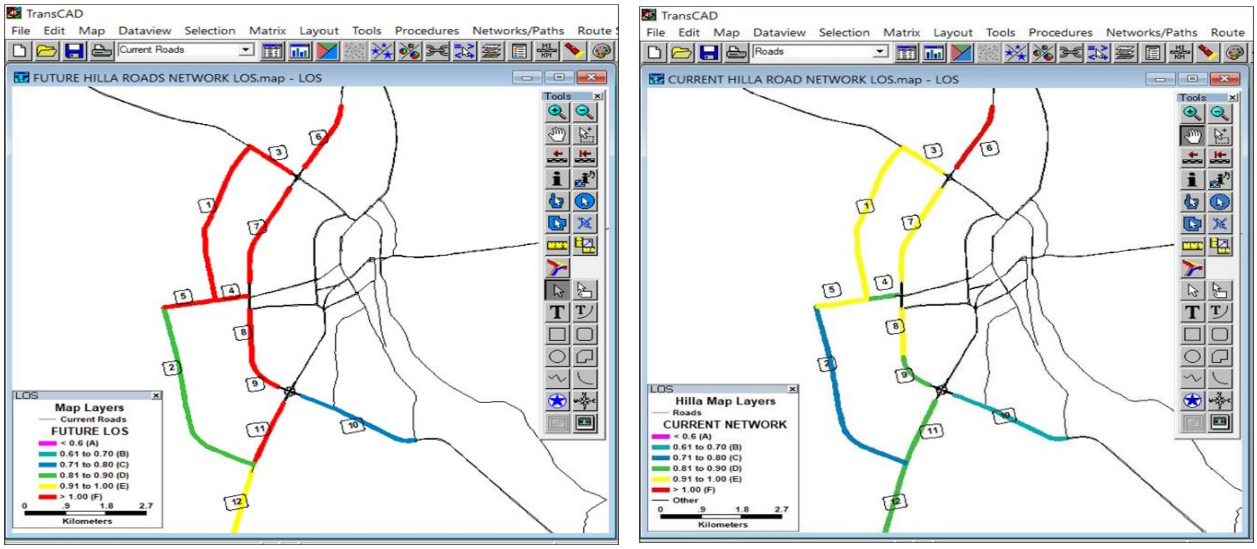
8. Effect of Implementation of the Suggested Roads on LOS for Current Freight Network in Hilla City

Traffic volume, capacity, and level of service data for the current freight network in Hilla city are listed in the Table 7, while Figure 8-a shows the level of service for the current freight network by the Trans CAD 4.5 program.

Table 7. The accounts of traffic volume, capacity, and level of service for the main road in Hilla city

Link No.	Direction	Road Name	Effective width (m)	Capacity (PC/hr/Lane)	Volume details		Equivalent total volume (PCU)	Volume capacity ratio	LOS.	Avg. LOS.
					Total volume (Veh/ hr)	Truck percentage %				
1	↑	80 ROAD (SECTION 1)	7.35	2940	2184	11.7	2712	0.92	E	E
	↓	80 ROAD (SECTION 1)	7.35	2940	2256	10.3	2752	0.93	E	
2	↓	80 ROAD (SECTION 2)	7.35	2940	1816	11.7	2256	0.76	C	C
	↑	80 ROAD (SECTION 2)	7.35	2940	1732	10.4	2108	0.71	C	
3	←	HILLA-KARBALLA ROAD	9	3600	2672	11.1	3296	0.91	E	E
	→	KARBALLA-HILLA ROAD	9	3600	3216	10.2	3896	1.08	F	
4	←	TOHMAZIA ROAD (SECTION 1)	7.35	2940	2073	10.7	2519	0.85	D	D
	→	TOHMAZIA ROAD (SECTION 1)	7.35	2940	2109	10.4	2547	0.86	D	

5	→	TOHMAZIA ROAD (SECTION 2)	7.35	2940	2328	11.7	2888	0.98	E	E
	←	TOHMAZIA ROAD (SECTION 2)	7.35	2940	2324	11.0	2836	0.96	E	
6	↓	HILLA-BAGHDAD ROAD	7	2800	2580	12.1	3236	1.15	F	F
	↑	HILLA-BAGHDAD ROAD	7	2800	2558	13.5	3274	1.16	F	
7	↓	60 ROAD (SECTION 1)	7.35	2940	2324	13.4	2980	1.01	F	E
	↑	60 ROAD (SECTION 1)	7.35	2940	2320	12.2	2920	0.93	E	
8	↓	60 ROAD (SECTION 2)	7.35	2940	2344	11.4	2920	0.93	E	E
	↑	60 ROAD (SECTION 2)	7.35	2940	2512	11.6	3112	1.05	F	
9	↓	60 ROAD (SECTION 3)	7.35	2940	2040	12.3	2544	0.86	D	D
	↑	60 ROAD (SECTION 3)	7.35	2940	2032	11.3	2494	0.84	D	
10	→	HILLA- DIWANIYAH ROAD	9	3600	1968	10.2	2392	0.66	B	B
	←	HILLA- DIWANIYAH ROAD	9	3600	1788	7.8	2084	0.57	A	
11	↓	HILLA- NAJAF ROAD (SECTION 1)	12.75	5100	3848	7.4	4488	0.88	D	D
	↑	HILLA- NAJAF ROAD (SECTION 1)	12.75	5100	3816	8.1	4536	0.88	D	
12	↓	HILLA- NAJAF ROAD (SECTION 2)	12.75	5100	3442	9.8	4146	0.81	D	D
	↑	HILLA- NAJAF ROAD (SECTION 2)	12.75	5100	3487	10.1	4241	0.83	D	



(a) At study year (2022) (b) At target year (2030)

Figure 8. The level of service for main roads in the city based on the modified network using Trans CAD 4.5 program

9. Evaluate the Future Level of Service for the Current Road Network at the Target 2030

The future total traffic volume for the freight road network in 2030 could be calculated based on current data of traffic volume in 2022 after multiplying the values of them with the 2030 rate of growth of vehicles in Hilla city (2.5%) as demonstrates below [14].

$$Total\ traffic\ volume\ (2030) = Total\ traffic\ volume\ (2022) \times (1 + \frac{2.5}{100})^8 \quad (1)$$

The future level of service value was recalculated from the ratio of the future traffic volume to the current capacity for each selected road.

Figure 8-b shown the final level of service outputs for freight network in Hilla city in the target year (2030) represented by a colour theme map of Trans CAD 4.5 program.

10. Level of Service for the Modified Network in Hilla City

The percentage of the (External – External) freight trips will be assumed to be approximately (50 percent) of the total freight vehicle volume on each road depending on the result of the questionnaire conducted from freight vehicle drivers. After reducing the volume of freight vehicles according to this ratio, the level of service for each road will be recalculated based on the modified traffic volumes, as shown in Figure 9 and Table 8 by Trans CAD program.

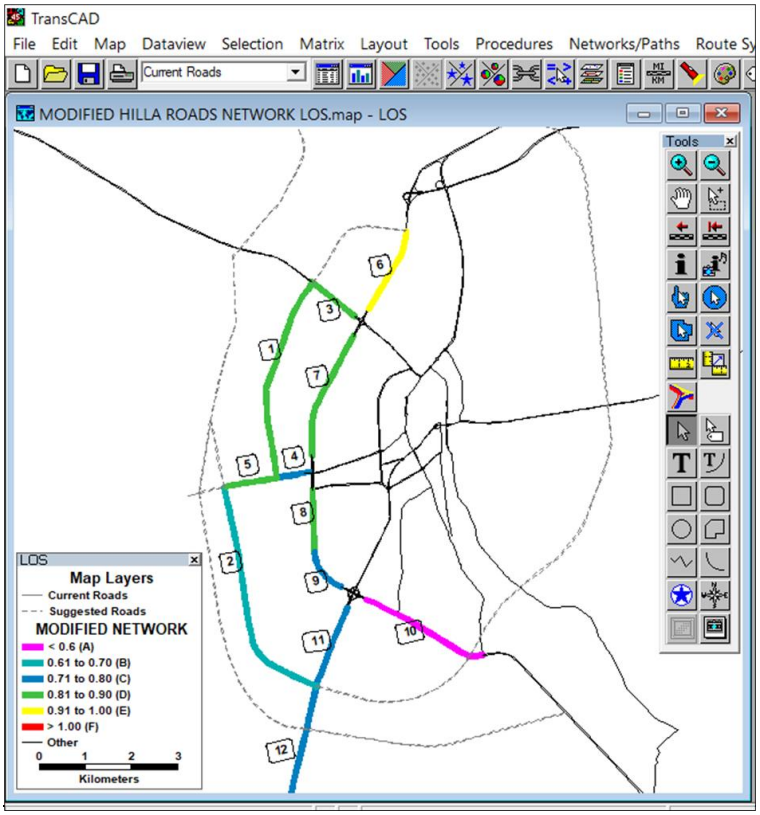


Figure 9. The level of service for main roads in the city based on the modified network in the study year using Trans CAD 4.5 program

Table 8. The accounts of traffic volume, capacity, and level of service for the main road in Hilla city after adding suggested roads

Link No.	Direction	Road Name	Effective width (m)	Capacity (PC/hr/Lane)	Volume details		Equivalent total volume (PCU)	Volume capacity ratio	LOS.	Avg. LOS.
					Total volume (Veh / hr)	Truck percentage %				
1	↑	80 ROAD (SECTION 1)	7.35	2940	2056	6.2	2328	0.79	C	D
	↓	80 ROAD (SECTION 1)	7.35	2940	2140	5.4	2404	0.81	D	
2	↓	80 ROAD (SECTION 2)	7.35	2940	1710	6.2	1938	0.65	B	B
	↑	80 ROAD (SECTION 2)	7.35	2940	1642	5.5	1838	0.62	B	
3	←	HILLA-KARBALLA ROAD	9	3600	2524	5.9	2852	0.79	C	D
	→	KARBALLA-HILLA ROAD	9	3600	3052	5.4	3404	0.94	E	
4	←	TOHMAZIA ROAD (section 1)	7.35	2940	1962	5.6	2186	0.74	C	C
	→	TOHMAZIA ROAD (section 1)	7.35	2940	1999	5.5	2217	0.75	C	
5	→	TOHMAZIA ROAD (section 2)	7.35	2940	2192	6.2	2480	0.84	D	D
	←	TOHMAZIA ROAD (section 2)	7.35	2940	2196	5.8	2452	0.83	D	
6	↓	HILLA-BAGHDAD ROAD	7	2800	2424	6.4	2768	0.98	E	E
	↑	HILLA-BAGHDAD ROAD	7	2800	2385	7.3	2755	0.98	E	
7	↓	60 ROAD (SECTION 1)	7.35	2940	2168	7.2	2512	0.85	D	D
	↑	60 ROAD (SECTION 1)	7.35	2940	2178	6.5	2494	0.84	D	
8	↓	60 ROAD (SECTION 2)	7.35	2940	2210	6.1	2518	0.85	D	D
	↑	60 ROAD (SECTION 2)	7.35	2940	2366	6.2	2674	0.9	E	
9	↓	60 ROAD (SECTION 3)	7.35	2940	1914	6.5	2166	0.73	C	C
	↑	60 ROAD (SECTION 3)	7.35	2940	1917	5.9	2149	0.73	C	
10	→	HILLA- DIWANIYAH ROAD	9	3600	1868	5.4	2092	0.58	A	A
	←	HILLA- DIWANIYAH ROAD	9	3600	1718	4.1	1874	0.52	A	
11	↓	HILLA- NAJAF ROAD (SECTION 1)	12.75	5100	3706	3.8	4062	0.79	C	C
	↑	HILLA- NAJAF ROAD (SECTION 1)	12.75	5100	3662	4.2	4074	0.79	C	
12	↓	HILLA- NAJAF ROAD (SECTION 2)	12.75	5100	3273	5.1	3639	0.71	C	C
	↑	HILLA- NAJAF ROAD (SECTION 2)	12.75	5100	3311	5.3	3713	0.72	C	

Figure 10 above shows a comparison between the level of service (LOS) for the freight road network in Hilla city depending on the average (V/C ratio) between the study year 2022 (based on a current and modified network) and the target year 2030 (based on current network capacity taking into account the growth rate in the traffic volume).

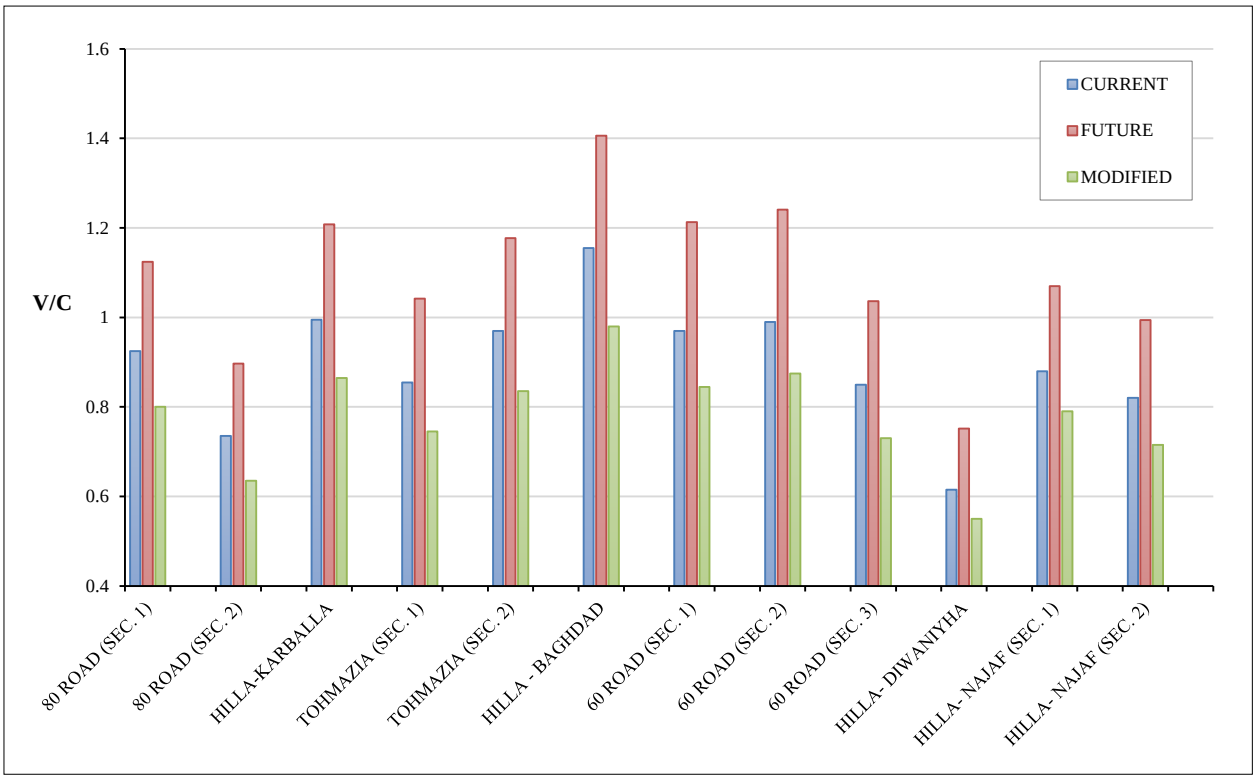


Figure 10. V/C Comparison between the study year 2022 (current and modified network) and the target year 2030

11. Effect of Implementation of the Suggested Roads on Drivers of Freight Vehicles

Adding the proposed roads and implementing them according to international specifications, and providing them with all the requirements for controlling traffic signs and lighting will encourage the drivers of freight vehicles to pass through them for many reasons, the most important of which are:

- The speed of freight vehicles on the proposed roads ranges from (60-to 90) Km/hr which is higher than the speed of the inner-city roads, which may reach 40 Km/hr within the crowded areas.
- The total traffic volume on the proposed road is less than the inner roads of the city.
- The number of intersections, turning areas, and pedestrian crossing areas in the suggested road are less than on inner-city roads.
- The suggested roads are connected to the main roads leading to the entrances and exits of the city without penetrating the city centre, which encourages drivers of freight vehicles, especially (External – External) trips, to pass through them.

12. Effect of Implementation Suggested Roads on the Current Hilla Road Network

The rapid and unplanned increase in the number of vehicles in the city of Hilla has caused many problems, including traffic congestion, a high rate of delay, and a poor level of service, because the current road network was designed in a period when the city's population was less, which in turn is linked to a limited number of vehicles where the road network can accommodate these vehicles. The carrying capacity of the roads in the city has become disproportionate to this increase in the number of vehicles, which has negatively affected the traffic flow in the city.

Therefore, adding a new road to the road network will reflect positively on the existing network by reducing the load on the internal roads of the city, reducing traffic congestion, and improving the level of service for it.

13. Conclusions

- When comparing the proposed routes by Arc GIS 10.4 network analysis tool for (external-external) freight trips on the current and modified network, find that all the proposed paths by the program pass through the new suggested roads for the modified network without passing through the city centre and inner roads;

- Based on the result of network analysis for the modified network by ArcGIS software, passing freight vehicles on the suggested roads will reduce the total (travel time and distance) for the same origin and destination points by 9%, and 30% from current distance and time respectively;
- The overall evaluation level of service for the current freight network depends on the results of the (V/C) ratio. Shown that the LOS for the study year 2022 is (D) based on current network data, and for the target year 2030, based on current network capacity taking into account the growth rate and increase in traffic volume is (F);
- Freight vehicles have a significant impact on traffic flow and the network's level of service. If the recommended network improvements are adopted, and the percentage of (external - external) trips is subtracted from the overall percentage of freight vehicles, the average level of service for the road network in the study year will improve to C.

14. Declarations

14.1. Author Contributions

Conceptualization, H.A. and A.A.; methodology, H.A.; software, H.A.; validation, H.A., A.A. and H.A.O.; formal analysis, H.A.; investigation, H.A., A.A. and H.A.O.; resources, H.A.; data curation, H.A.; writing—original draft preparation, H.A.; writing—review and editing, A.A. and H.A.O.; visualization, H.A.O.; supervision, A.A. and H.A.O.; project administration, A.A.; funding acquisition, H.A. All authors have read and agreed to the published version of the manuscript.

14.2. Data Availability Statement

The data presented in study are available in the article.

14.3. Funding

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14.5. Conflicts of Interest

The authors declare no conflict of interest.

15. References

[1] Engström, R. (2016). The Roads' Role in the Freight Transport System. Transportation Research Procedia, 14, 1443–1452. doi:10.1016/j.trpro.2016.05.217.

[2] Regan, A., Holguin-Veras, J. O. S. E., Chow, G., & Sonstegaard, M. H. (2000). Freight transportation planning and logistics. Transportation in the New Millennium: State of the Art and Future Directions, Transportation Research Board, National Research Council, Washington, United States.

[3] Cui, J., Dodson, J., & Hall, P. V. (2015). Planning for Urban Freight Transport: An Overview. Transport Reviews, 35(5), 583–598. doi:10.1080/01441647.2015.1038666.

[4] Jamilah, W., Syafi'i, & Handayani, D. (2018). Impact of freight transportation on road network performance in Surakarta with toll road scenario. AIP Conference Proceedings. doi:10.1063/1.5042987.

[5] Deng, J. S., Wang, K., Hong, Y., & Qi, J. G. (2009). Spatio-temporal dynamics and evolution of land use change and landscape pattern in response to rapid urbanization. Landscape and Urban Planning, 92(3–4), 187–198. doi:10.1016/j.landurbplan.2009.05.001.

[6] Allen, J., Browne, M., Piotrowska, M., & Woodburn, A. G. (2010). Freight Quality Partnerships in the UK: an analysis of their work and achievements. Green Logistics Report, University of Westminster, London, United Kingdom.

[7] Short, J., & Kopp, A. (2005). Transport infrastructure: Investment and planning. Policy and research aspects. Transport Policy, 12(4), 360–367. doi:10.1016/j.tranpol.2005.04.003.

[8] Browne, M., & Allen, J. (2011). Enhancing the sustainability of urban freight transport and logistics. Transport and communications bulletin for Asia and the Pacific, 80, 1-19.

[9] Ali Al-Anbari, M., Hadi Abedali, A., & Abdul Ameer Alwash, A. (2018). Transport Sustainability Index of Main Arterials at Hilla Case Study (Safety and Environmental Aspects). Journal of Engineering and Sustainable Development, 22(02), 106–117. doi:10.31272/jeasd.2018.2.38.

[10] Medlol, S. G., & Alwash, A. A. A. (2020). Economic, Social, and Environmental Sustainable Operation of Roadways within the Central Business District (CBD) sector at Hilla City Incorporated with Public Transport. IOP Conference Series: Materials Science and Engineering, 928(2), 22100. doi:10.1088/1757-899X/928/2/022100.

[11] Blumentrath, C., & Tveit, M. S. (2014). Visual characteristics of roads: A literature review of people's perception and Norwegian design practice. Transportation Research Part A: Policy and Practice, 59, 58–71. doi:10.1016/j.tra.2013.10.024.

[12] Fischer, M. M. (2006). GIS and network analysis. Spatial Analysis and GeoComputation: Selected Essays, 43–60. doi:10.1007/3-540-35730-0_4.

[13] Nautiyal, A., & Sharma, S. (2021). Condition Based Maintenance Planning of low volume rural roads using GIS. Journal of Cleaner Production, 312, 127649. doi:10.1016/j.jclepro.2021.127649.

[14] Modinpuroju, A., Prasad, C. S. R. K., & Chandra, M. (2016). Facility-based planning methodology for rural roads using spatial techniques. Innovative Infrastructure Solutions, 1(1), 1-8. doi:10.1007/s41062-016-0041-8.

[15] Abousaeidi, M., Fauzi, R., & Muhamad, R. (2016). Geographic Information System (GIS) modeling approach to determine the fastest delivery routes. Saudi Journal of Biological Sciences, 23(5), 555–564. doi:10.1016/j.sjbs.2015.06.004.

[16] Llagostera, P., Comas, C., & López, N. (2022). Modeling road traffic safety based on point patterns of wildlife-vehicle collisions. Science of the total environment, 846, 157237. doi:10.1016/j.scitotenv.2022.157237.

[17] Ding, H., Cai, M., Lin, X., Chen, T., Li, L., & Liu, Y. (2021). RTVEMVS: Real-time modeling and visualization system for vehicle emissions on an urban road network. Journal of Cleaner Production, 309, 127166. doi:10.1016/j.jclepro.2021.127166.

[18] Hakkert, A. S., & Gitelman, V. (2014). Thinking about the history of road safety research: Past achievements and future challenges. Transportation research part F: traffic psychology and behaviour, 25, 137-149. doi:10.1016/j.trf.2014.02.005.

[19] Du, J., Ren, G., Liu, W., & Li, H. (2022). How is the visual working memory load of driver influenced by information density of traffic signs. Transportation research part F: traffic psychology and behaviour, 86, 65-83. doi:10.1016/j.trf.2022.02.007.

[20] Obyesa, R. K., & Alwash, A. A. A. (2021). Development Trip Generation Model of Al-Salaam Sector within Hilla City, Iraq. Design Engineering, 5800-5808.