Analysis Travel Pattern of Freight Demand Using GIS Techniques

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Abstract. Freight transportation plays a major role in determining the economy of a region. Efficient freight transportation systems are typically associated with reducing the cost of moving goods from and to logistics facilities. The objective of this study is to evaluate the intercity road freight network and particularly analysis trip pattern of intercity truck traffic, using the collected freight data and GIS techniques. Freight data is collected through roadside and interviews surveys which represent the main data source of this study. Various analyses for freight demand is carried out using GIS techniques, the output of this study is useful for decision makers to apply the correct decisions.

Keywords: Freight Transportation, GIS Techniques.

1. Introduction
Freight transportation plays a major role in determining the economy of a region. Efficient freight transportation systems are typically associated with reducing the cost of moving goods from and to logistics facilities. Understanding the clustering pattern of truck trip ends (i.e., productions and attractions) can help optimize the location of such facilities over space [1]. Transportation provides the means to travel for implement daily work activities, and it is a necessary condition for human activities, such as commerce, recreation, and other [2]. In recent years, growth rate of vehicle ownership in Baghdad is increased by 5.5% after 2003 and the growth is stable at 3.5% after 2006, Asmael and Alkawaaz 2019 [3]. This high growth of private vehicles conflict with high increase in truck travel which make the condition worse in Baghdad city.
This process aims to create predictive statistical models that describe the behavior and relationship of a phenomenon and not to reconsider it. In practice, it is not easy to develop a model from field data, because the fact that many phenomena are nonlinear and / or overlapping or that it is difficult to derive a model (4). The city of Baghdad, 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 the future ones [4]. This study tries to analysis travel pattern of freight demand and explore different characteristics effect on good transportation. The analysis consists also the logistics facilities.

2. Case study

Baghdad governorate extends from Salah Alden in the north, to Babil in the south, to Diyala governorate, east to Al-anbar, and west in Iraq area. It lies within (38N) zone according to UTM (Universal Transverse Mercator) geographic coordinate system. Local study region extends between latitude (32°40' 00" to 34° 00' 00") north and longitude (44°00' 00" to 44°20' 00") east, the area of Baghdad is (5065.163 sq.km) representing 1.04 % of the total area of Iraq. The smallest governorate of area in Iraq, and in 2018 Baghdad comes first in terms of population, with 9 million people [5]. The region of Baghdad is characterized by the passage of the Tigris River, during which it is divided into two parts, Al-Karkh and Rusafa, and the study is divided into 9 districts and will be mentioned later. Generally, road networks comprise of three classes of roads [6]:

- Major arterial: These connect main towns and governorates, they carry mostly long-distance traffic that is either generated in the towns or collected from the rural areas by the secondary and local roads.
- Minor arterial: these connect small towns and groups of villages and link these areas into the primary road network.
- Collector roads: these connect the more lightly-populated rural areas into the secondary and primary road network. They also provide access to individual plots such as farms and homes, usually these roads are unpaved or poorly paved.

In our study, the analysis was done on the main and secondary roads leading to the center of Shorja. There are six main roads which link Baghdad with the other governorates; it also links districts outside the boundaries of the Municipality of Baghdad with the interior districts as illustrated in Figure (1).

- The length of the Primary roads completed is 486 km.
- Lengths of Secondary completed roads are 763 km.
- The length of the completed rural roads is 30.5 km.
- The length of the completed bridges is 886.5 m.
- The number of fixed bridges 34, [7].

Figure 1. Entrances of Baghdad city for Freight Demand.
3. Methodology

The aim of this research is to assess the system of freight transportation in the city of Baghdad through applying the transport planning process using geographic information systems (GIS), explore existing problems and alleviating the challenges. The main objectives are:

- Collecting information related to the freight transportation system in the governorate to facilitate the tasks of the decision-maker to develop freight network.
- Building geodatabase of road network of Baghdad city using the appropriate transportation planning program like ARC GIS.
- Preparation of a truck traffic database including the following:
  - Vehicle movement survey (knowing the origin and destination within the governorate through questionnaire)
  - Count the shipments and truck demand on the internal road network from the entrances to the city through survey during selected time interval for entrance to the city.
  - Analyzing the current state of freight transport routes in Baghdad based on reliable hand surveys and GIS.

4. Data Collection

It is the process of conducting traffic surveys for all of Baghdad governorate due to lack of adequate data for the city and the difficulty receiving it completely from the authorities concerned, therefore, the survey was done manually at the entrances to the governorate. As for the remote control devices were not approved to be used for security reasons for the country. Another dataset used in the analysis was based on the Commercial Vehicles Survey (CVS) of the Ministry of Transportation / Public Land Transport Company. The Commercial Vehicles Survey (CVS) is a survey of truck drivers that was conducted at the entrances of Baghdad and important places for the gathering of drivers, for example (Alwa Al Rasheed, the entrance to the Doura refinery, the areas of exchange for vehicles, etc.) to collect detailed information about the movement of trucks and goods on the main roads and highways of the province. The survey collects information about freight, vehicle, and goods from randomly selected trucks on highways and international border crossings information from the transportation company as well as some government trips for commercial transportation. Trip details, goods and vehicle characteristics, including weights and axles, are collected from selected trucks from across the city at more than one directional survey site. As shown in the attached questionnaire in the appendix.

The surveys will be as follows:

- Truck volume exit and enter from the city.
- Personal interviews with drivers entering the city.
- The purpose of the trip.
- Traffic problems for road users.
- Origin and destination for trips through city center.
- Truck stops (Area and Location)

The truck demand travel pattern data was collected using manual survey. The truck volume was calculated by using the questionnaire and personal interviews with drivers at road side and at the entrances to the city. The questionnaire contained the origin and destination of the trip, the time that the driver stops, the problems they face, and the most important thing from the questionnaire is the truck volume per hour. Due to difficulty in collecting data from the entrances and exits due to the security conditions, therefore, the period for data collection was divided into two hours in the morning and two hours in the evening, to collect freight transportation demand used in this study.

5. Baghdad Truck Demand

The most important points in the site were chosen to control the surveys of the city, as these points were distributed at the entrances to the city as shown in Figure (1). These seven stations were monitored by means of field surveys and the GPS and shows the entrances and their movement and passage into the
city. Figure (2 and 3) illustrate the flow of truck demand and difference between the morning and evening periods. The Abu Ghraib entrance is divided into two parts, the new and the old Abu Ghraib, the new entrance is not included in the surveys because it is an entrance for small vehicles, and the old entrance is for trucks. From all this, it appears that the old Abu Ghraib entrance generates the largest number of trucks, and this is because the private sector trucks are diverted from the southern (Yusufiyah) entrance to the old southwestern entrance to Abu Ghraib.

![Comparison of Truck Volume According to Days](attachment:image1)

**Figure 2. Traffic Volume of Freight Vehicle in Entrance.**

![Comparison of the Morning & Evening Period at Monday and Wednesday](attachment:image2)

**Figure 3. Truck Volume of Freight Vehicle According to Time periods on (a)Monday and (b)Wednesday.**

6. Building Geodatabase of Freight Network System in GIS

The satellite image of the city of Baghdad was taken from the Baghdad Municipality Directorate (the Geographic Information Systems Unit), GIS technology is not included in data survey but to define
directions and locations of sections [8]. There for, the data for the links shape file were drawn. Three basic types of data were collected. The first data were descriptions attributes, which give descriptions such as roads (length, width, number of lanes, speed limit, amplitude, etc.), and the rest was obtained from observation and measurement, which play the primary role in analyzing the route to find the optimal path location, and the features table includes the most important features of the road length measured in kilometers, speed (km per hour), road width and direction, and the number of lanes.

The Database contains also data for 2016 and 2018, 2020 of traffic volume data for passenger car. Data apply to it a set of procedures for manipulating the data and creating source and destination information (O-D matrix). The O-D data can be used to determine the volume of goods transported in Baghdad by trucks between the entrances and the most important unloading areas that have been identified on the basis of interviews and consider (entrances) the area of origin and (commercial areas) the destination area. [9], [10] and [11].

7. Freight Network Analysis using GIS
After the geodatabase is ready for analysis, building network analysis is essential for analysis. In the GIS software version 10.7, selecting the best route for the freight demand is a simple matter as it takes after collecting data, entering it, defining road network characteristics and analyzing the network at one destination, which is the Shorja zone (Al Wathba intersection) and focusing on network characteristics with dependent properties (Time) and features (Traffic volume, speed, road capacity and other road characteristic). The method of finding the best route focuses around the most important characteristic, which is the impediment by the time of a trip and the choice of the day, the week, and the time in the morning or evening, and the time in the hour to fit with the speed unit of the km / hour as shown in Figure 8 above, and from which the best route for the chosen stop (the Al Wathba intersection) is produced, and on which it is located. After entering the data in the geographic information systems GIS, and defining the data and their characteristics, the data are analyzed and important results are produced for researchers and users, and among the most important analyzes that will be worked out are (the best route between origin and destination, O-D cost matrix, converge area) and using statistical analysis (kernel density analysis) for production and attraction sites.

7.1 O-D Cost Matrix
An origin and destination cost matrix can be created for deliveries from the portals to each region specific commercial district. The results of this matrix can be used to determine the commercial areas served by each route and the time that each route takes to the destination. Also, the total driving time from each entrance to a destination for the loaded goods can be found. As shown in figure (4).

7.2 Best Route Analysis of Iraq Road Network
The main purpose of finding the best path for the freight based road network is to know and define the main roads from the borders of Iraq until they enter the governorate of Baghdad. The analysis was done by identifying the main Iraqi roads that start from the Iraqi borders, the origin region, and the entrances to Baghdad governorate, the destination area. As shown in figures (5-10).
Figure 4. O-D Cost Matrix (Baghdad Entrances-Commercial Center).

Figure 5. Best Route to Jisr Diyala Entrance.

Figure 6. Best Route to Yusufiyah Entrance.
Figure 7. Best Route to Abu Gharib Entrance.

Figure 8. Best Route to Rashdiya Entrance.

Figure 9. Best Route to Al-Tajy Entrance.

Figure 10. Best Route to Khan Bani Saad Entrance.
7.3 Best Route Analysis for Baghdad Road Network
Analyzing the best path for roads is one of the important analyses that help road users to choose the best route, according to the morning and evening periods, depending on traffic volume, time, distance and road capacity, as mentioned previously. As in the following figures (11-14) that show the analysis of each entrance and the best route for it to the commercial city center (Shorjah).

**Figure 11.** Best Route for Al-Taji Entrance.

**Figure 12.** Best Route for Abu Gharib Entrance.

**Figure 13.** Best Route for Rashdiya Entrance.

**Figure 14.** Best Route for Jisr Diyala Entrance.
The current route used by truck vehicles is different than the best route appeared in GIS analysis as shown in Figure 15. The entrances to Baghdad, especially the Sha’ab entrance and Jisr Diyala entrance, suffer from high traffic congestion due to poor services and the large traffic volume for them. To solve this problem, a solution was proposed by add new road to connect Al Sha’ab directly with Muhammad Al-Qasim highway which facilitate passing truck vehicles to enter Muhammad Al-Qasim highway without passing in Al Sha’ab district which reduce many traffic congestions in this area. A solution to this problem give a faster and better path to the Sha’ab entrance to Al Shorja is proposed. Where the proposed path is from the main streets and enters Muhammad Al-Qasim highway directly at a detour near the entrance, which helps to quickly reach Al-Shorja. As shown in the figures (15) and (16).

![Figure 15. Current Route to Al-Sha’ab.](image1)

![Figure 16. Suggested Route to Al-Sha’ab.](image2)

7.4 Coverage Service Area

It is an analysis to know the city of Shorja, the amount of space it covers for the most important commercial areas, where Shorja was used as the origin point and the commercial areas as the destination point, the analysis is done either by the distances and the boundaries of the surrounding area or by time, the analysis was used in time for a period of 15 minutes, which is equivalent to 0.15 hours, as shown in the figure (17).
In order to gain a better understanding of the available data and be able to visualize the trucking trip patterns, a kernel density analysis was conducted. Kernel density estimation is another very useful statistical tool or technique used to create smooth curves or surfaces given a set of data. It is a popular technique utilized for spatial data analysis, done through the use of counts per unit area. The density of the core will be analyzed for two directions, the first for the city entrances (areas of origin) and the second for the attractions (the cargo discharge areas).

First Analysis (Entrance Areas)

The traffic volume density appears at each entrance and explains in a graphic manner the amount of traffic entering and exiting at each of them. We conclude that most of the entrances increase in intensity at the entrance (Abu Ghraib) and decrease at the entrance (Yusufiyah), and the reason was mentioned earlier. As for the (Jisr Diyala) entrance, it also had a high density, and the reason was due to poor services, which made high stops for entry and exit, so the traffic volume is high per hour in the area. As shown in figure (18).

Second analysis (Attractions Areas)

In this analysis, the truck volume density from the entrances appears, then it gradually increases towards the city center, where the attraction of trips increases, and the most concentrated area of truck volume is at the intended study area in the paper (Al Shorja). As shown in Figure (19).

Freight Travel patterns concentrate in the center of Baghdad in particular, and gradually lack services on the outskirts of Baghdad due to the poor conditions that the country is going through, which made the

Figure 17. Coverage Area of Shorja

7.5 Kenral Density Statistical Analysis

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most suitable place for trade is the center of the capital and defining the (Shorja) area, the intersection of Al-Wathba Place of study (destination).

Figure 18. Kenral Density at Entrances.  
Figure 19. Kenral Density at Attraction Areas.

8. Road network level Assessments
The network is evaluated through two parts, the first section is the capacity and the second section is the level of service, and the two are linked together. Capacity is the maximum number of vehicles and is evaluated through it by the value of the traffic volume for the road capacity (v/c) and the corresponding level of service. The level of service is closely related to the capacity.

After analyzing and determining the best route, information is obtained for the route and its characteristics such as speed, trip time, distance traveled, and (v/c) value. as shown in Table 1. After defining the routes, the layer was analyzed to isolate the traffic volume for road capacity (v/c) for the morning and evening periods.as shown in figures (20) and (21).

| Attribute                      | Value               |
|--------------------------------|---------------------|
| First Stop ID                  | Abu-Gharib Entrance |
| Last Stop ID                   | Al-Wathba Intersection |
| Total Distance                 | 20.035 km           |
| Speed                          | 92 km/hr            |
| Time                           | 13.2 minutes        |
| Traffic Vol. in Morning        | 287                 |
| Traffic Vol. in Evening        | 276                 |
| V/C                            | 0.56                |
| Traffic Vol. of Passenger Car  | 4927                |

Table 1. Information about the best route (Abu Gharib).
Through the application of the best way to analyze the road network and also through the traffic surveys that were applied at the entrances to the city and some points in the city center, it was observed that the concentration of traffic congestion occurs in the morning period, which is a crowded market, the largest center for goods and most government departments, and this resulted through Analysis in the GIS program, where the color was clearly violet, representing the ratio 0.3 in many connections. About 100 of them are links to the commercial city (Al Shorja) that have a type of D type services between their appearance after the other of the proportions (v / c) Then in general in the road network of the city of Baghdad surrounding Al Wathba is the service level type D, which represents (v / c) from (0.40-0.70) that appeared in several colors to change at the entrance to the Diyala Bridge and that is due to poor services As in the evening period, the network is summarized by the blue color, but it changes with the pink color in the commercial and entertainment centers in the evening and its lower in the rest of the network. As shown in the figure (20) (21). From the above analyzes, it was found that the evening period is easier and more flexible for truck drivers, due to the reduced traffic volume in the city center and the ease of unloading, which is noticed that the traffic volume outside Baghdad in the evening is more than the morning period. This helps to suggest times for the entry of trucks, which helps in flexibility of movement and not affecting the traffic volume of the Passenger Car during working hours.

9. Conclusions
1- Various best routes for freight demand is presented using GIS network analysis
2- Suggested route to solve Al- Sha'ab entrance problems to facilitate passing truck vehicles is presented.
3- Through Kenral density, it is appeared that the attraction of trips is toward center of Baghdad, so reconsideration to relocate unloading area is essential to reduce the congestion.
4- It appears that the old Abu Ghraib entrance generates the largest number of trucks.
10. Recommendations
-The route for external trips must be changed that passes through the network, Rehabilitation of the highway that passes from the Diyala Bridge for trips heading to Baghdad.
- Preparing and maintaining the collector roads for trips heading to the governorate center and other roads and establishing a ring road (Hawli Baghdad) to transport external trips without going through the city center. In order to increase the capacity of congested connections
- propose unloading places for cargo far from the city center (transport exchange areas), taking the opinion of drivers in these places and transporting them in smaller vehicles to allow greater capacity for roads heading to the city, and the transportation route for these links should be expanded in addition to Traffic management procedure.
- New roads must be added to the existing network.
- Allowing private vehicles to pass through the entrance to Al-Yusufiyah to reduce the traffic burden at the Abu Ghrabi entrance.

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