



## Estimating Parking Demand for Commercial Areas in Baghdad- Iraq

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### ABSTRACT

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In many areas of Baghdad, the capital of Iraq, there has been an unplanned and random shift in urban land use where a significant portion of the residential land within the city has been converted to commercial uses. This alteration in land use has led to severe traffic congestion due to the influx of vehicles frequenting these areas, the streets' insufficient capacity to handle the vehicular traffic, and a lack of adequate parking spaces. The research aims to develop a statistical model to calculate the needed parking spaces in Baghdad's commercial areas. It is estimated that the required vehicle parking can be determined by the areas of the buildings. The research concludes that certain commercial activities, such as restaurants and stores, necessitate more vehicle parking compared to other commercial activities, and the demand for parking spaces is directly proportional to the commercial activities' area.

## 1. INTRODUCTION

Traffic congestion on urban streets constitutes a major problem in many countries of the world, especially developing countries [1, 2]. Urban development plans focus on transport as a vital factor in the development and effectiveness of the city [3]. Urban transport planning includes organizing traffic routes for all kinds of transport concerning urban land uses [4-6]. The inefficiency of public transport networks and their modes has in turn led to an increase in private vehicle ownership in the urban transport system [7, 8], and thus the generation of traffic congestion, as the need for movement and movement is indispensable for many categories of urban society, as the ownership of private vehicles is a measure of individual income and lifestyle for the society [9, 10]. Therefore, providing adequate parking lots in urban areas is considered a challenge and a priority for many cities in the world, and the need for parking lots emerges continuously as long as urban areas are constantly evolving [11].

Urban land uses vary in their need for vehicle parking, as commercial uses, shopping centers, and commercial units constitute a high traffic momentum, such as restaurants and hotels, more than the rest of the urban land uses [12]. The lack of sufficient vehicle parking in urban areas is one of the most important problems facing the majority of the world's developed and developing cities [13, 14]. The most important reasons for this problem are the scarcity of allocating land as parking for vehicles within the district plans of cities and the preference for other uses of land that generate more returns [15]. With multiple departments such as the Transport Authority, Traffic Directorates, and the municipality responsible for the master plans law... etc., the fees imposed

and collected on parking constitute an important factor in many vehicle owners resorting to parking their vehicles in undesignated areas to avoid paying sums to park their vehicles [16], in addition to discouraging the private sector to invest in establishing parking lots within urban areas is one of the policies that is rarely pursued in city administrations due to the scarcity of urban land [17].

The lack of parking spaces for vehicles within urban areas leads to an increase in congestion because motorists resort to parking their vehicles within the streets of the urban area and in many cases encroaching on the rights of pedestrians and cyclists by parking vehicles on the sidewalk, this situation leads to an increase in congestion and unrest among users The road and cause risks to the movement of users, especially children and the elderly [18]. As for the administrative aspect of the process of regulating the parking of vehicles on the street, allowing irregular parking, parking of vehicles for long periods, or allowing abandoned and idle vehicles to be left on the street, in addition to not imposing fees for parking vehicles, not issuing instructions to regulate the parking of vehicles, and not punishing violators make it difficult. Estimating the harmful effects caused by the problem of the lack of vehicle parking in urban areas on road users, residents, and users of urban areas [19]. The issue of studying the need for car parks has become an urgent necessity, as vehicles, especially private ones, are constantly increasing and the rate of increase varies from one urban area to another, which makes the process of predicting the need for car parks relatively complex, as the city is dynamic in change and the needs of its residents are constantly changing.

In their study published in 2023, Al-Tamimi et al. [10] discussed the standard of parking lots in commercial city

centers, where the set of application of standards of parking for some countries was dealt with based on the importance of these parking in providing easy access to the movement system, and that failure to provide them would hinder the urban transport system and cause congestion, pollution, noise ... etc. It was done through a field survey on both sides of the road for the study area in the center of the city of Shatrah in the Iraqi province of Dhi Qar, and with the help of the GIS environment to represent these surveys by determining the nature of the use of buildings, their ownership and prices, as well as the use of descriptive and quantitative analysis tools and applications of spatial analysis in GIS applications and statistical analysis represented by the normal distribution“ binomial”, as the results were limited to determining the area needs of parking lots based on surveys, planning and design standards for the road, and the results of statistical analysis, as well as a set of procedural solutions represented by changing the use and ownership of buildings to provide these parking lots [20].

Hassine [21] diagnosed the problem of the time it takes the driver to search for parking options for vehicles, as it aimed to study the behavioral factors of vehicle drivers in determining appropriate parking options by following a methodology based on a logarithmic model to understand their behaviors for three alternatives to parking (on-street, off-street, and underground). The relationship between these behaviors and land use planning, enforcement level, parking pricing and time, and indicated the importance of using GIS in directing the behavior by assisting in decision-making regarding parking options compared to price, time, and effort factors [21].

Al-Tamimi et al. [10] dealt with the characteristics of off-street parking lots by adopting a methodology based on the license plate to analyze and evaluate data related to parking, as it was allocated to two categories, The first is the locational factors that relate to buildings and land uses, and the other is the parking characteristics, which include (the duration of parking, peak hours, the average period of vehicle downtime). The study concluded the failure to use the technologies related to the electronic payment system has made the demand exceed the available supply with the studied factors, which generates problems of parking, exiting, and entering parking lots in the studied area [9].

Parmar [22] studied the relationship between the characteristics of the demand for car parks and the driver's behavior in choosing a parking place using statistical models such as (linear regression, least square regression, unit graph technique ...etc.), and the need to include demand factors in the stages of planning, urban design, and transportation plans. The study found an increase in the supply of car parks It does not represent a sustainable solution to the problem of parking for vehicles. Rather, the elements of sustainability related to changing the pattern of behavior of individuals must be integrated and reflected in the built environment towards pedestrian movement, bicycle use, public transport, and the provision of urban infrastructure that supports this type of transformation [22].

Al-Mosawy [23] raised the issue of space limitations in cities and the problem of their inability to accommodate a large number of vehicles. The article assumed that the use of parking technologies and systems to solve the problem of limited space would provide effective solutions for the required parking lots by setting a goal represented in providing parking lots to accommodate the largest number of vehicles

when lands are limited, scarce, expensive and competitive, including to determine the design aspects of the parking lots and their area and their relationship to residential and commercial use in the city of Dubai in the United Arab Emirates by studying the five projects of the parking lots in Dubai city center by determining the capacity indicators and the area of each floor and the number The roles, the estimated total area, the number of entry and exit cabins, and the vehicle retrieval time, and a conclusion was reached that the design and planning indicators can be calculated with the capacity and efficiency of the urban land to accommodate parking projects concerning the allocated space. Field studies of projects in the city of Dubai, a study that helps researchers, planners, and designers determine the optimal design of parking lots and its relationship to building systems in urban planning and design [23].

Khordagui [24] focused on the impact of parking prices on people's behavior from a socio-economic perspective by relying on a household survey of a sample of people from California, where the study faced two obstacles. The first one was estimating the need for parking for those who do not use their private cars to reach work areas. The second is to estimate the size of the positions that the employer provides by paying wages and incentives for their use of this service (vehicle parking), by adopting two hypotheses, The first assumes that the stakeholder pays the price allowance or incentives to the employee working for him in exchange for using this service to access his work, while the second assumes that he does not pay the price allowance or incentives to the employee, Where the results showed in both cases that in the case of raising the parking price, it reduces the use of private cars, and therefore it has a major role in managing the demand of parking, and it has to reduce pollution and traffic congestion and encourage behavior towards using other means of public transportation [24].

Based on the previous literature, some of which included the effect of site characteristics or the behavior of individuals in thinking about obtaining parking lots and studies related to the impact of prices, while studies included the need for parking in the central area of the city or the impact of parking pricing on the behavior of individuals. Therefore, this article comes to estimate the need for parking in commercial sites within residential neighborhoods, which witnessed the Iraqi capital in Baghdad transforming large parts of residential use into commercial in light of the high standard of living of society and the increase in demand for these parking within residential neighborhoods.

## 2. RESEARCH METHODOLOGY

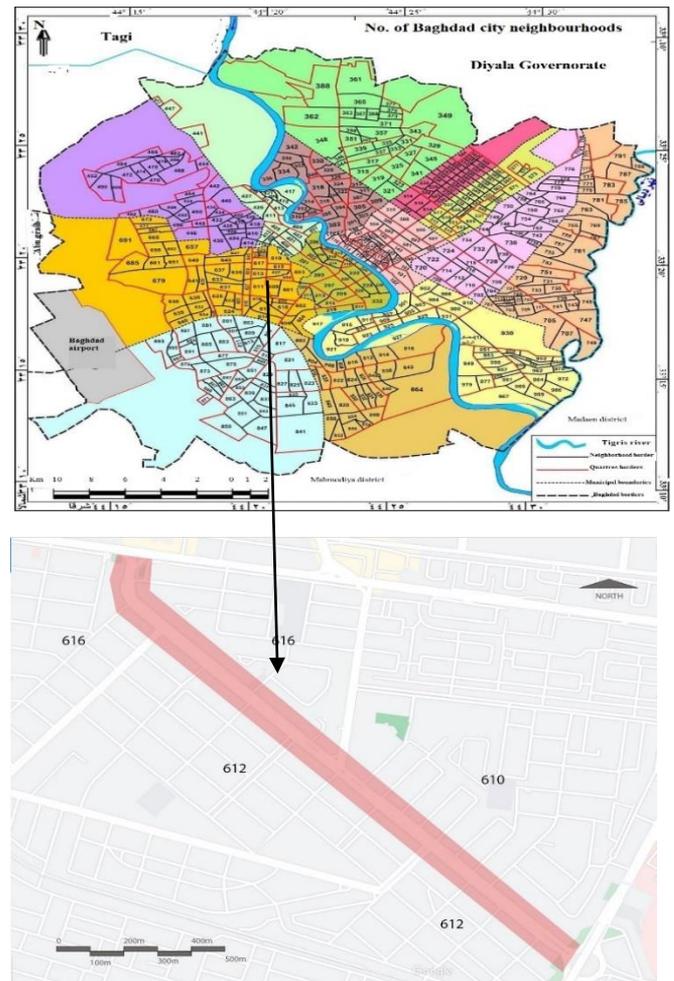
The research assumes that the reason for the traffic congestion in the commercial areas is the lack of parking lots in sufficient numbers. Vehicles are required according to the type of business activity. To verify this hypothesis, the study relied on an analytical methodology based on building a database for the selected sample and conducting statistical analyses through SPSS programs to arrive at an explanation of the behavior of the variables (factors) that have been studied and identified a set of indicators that can explain the relationship between the commercial activity in the studied area and the need for car parks by adopting statistical modeling of three functional relationships for the commercial units (commercial land uses) and its relationship to (the number of

daily frequented vehicles, the average vehicle parking times [25], and the average duration of daily activity). The study will rely on a field survey and a questionnaire of users of the commercial street for samples selected from the commercial buildings for neighborhoods of Yarmouk neighborhoods no. 610, 612, and 616, the selected study area was chosen due to the rapid extend in commercial land demand, especially after the year 2020. Study area maps obtained from the Baghdad Municipality regarding land uses, photographs taken by the researchers, and statistical programs for building and modeling the results, to achieve the aims of the study, there is a need for specific data for commercial units and vehicular traffic in the study area, in-site survey for commercial units aims to collect data for units' type, counts, areas and activity duration, for vehicles it's important to have data on vehicles frequency, time for parked vehicles and vehicles parked irregularly in streets, in-site survey was completed in Feb. 2022. Collected data were organized as a spreadsheet using Excel, data were analyzed by two levels, first, by sorting to find correlations of factors studied, and second, by generating graphical representations that describe the behaviors of studied factors to find the suitable estimation model. A survey sample was taken, not an experimental sample, by taking 10% of the users of the street, including vehicle drivers and shoppers, at peak times, i.e., the start and end times of work, and the times of shopping, outing, and wandering around shops and restaurants. Then the linear regression model was adopted because it takes some independent variables to determine their effects on parking demand and what size is required to solve the problem. The validity of the model was proven through the F-statistical test to evaluate the model.

### 3. CASE STUDY

The city of Baghdad is witnessing heavy traffic congestion in most of its urban areas due to many reasons, including the continuous increase in the number of vehicles, insufficient street capacity to accommodate the increasing number of vehicles, mixing and randomness, illegal abuses in urban land uses, the increase in demand for commercial uses, and the transformation of many residential areas. to commercial areas randomly and unplanned [9]. In addition to the lack of traffic development plans, urban transport, and security measures that included closing many roads, setting up checkpoints inside the city, and poor enforcement of the traffic system [10], the researcher believes that, in addition to the above, the lack of Adequate parking lots in urban areas, poor enforcement of parking controls by the municipal authorities responsible for issuing building permits, and failure to update data on the need for parking lots in urban areas are the main reasons for the problem of traffic congestion. The importance of the research lies in trying to reach quantitative standards related to the number of vehicle parking spaces required according to the use of commercial land and the type and area of the commercial unit. The study was conducted in the city of Baghdad / Al-Karkh district / Al-Mansur district / Al-Yarmouk neighborhood / Street (17) No. (610, 612, 616) on 5/27/2022, and for a sample area of (20) hectares, This area in the city of Baghdad was chosen as a model of one of the change processes that occurred in the city of Baghdad in the transformation of land use from residential to commercial as a result of the city master plan not responding to economic growth and the consumer nature of society as a result of the high standard of living and the basic plan not accommodating the functional

changes in the city. Making these residential streets replace the commercial function that did not perform its function as planned in the city's master plan created many problems in the spatial structure of the area, including the lack of sufficient parking lots to accommodate the commercial function that appeared in this area.as shown in Figure 1:



**Figure 1.** Al-Yarmouk Quarter in the city of Baghdad, Street (17), which consists of residential neighborhoods (610, 612, 616)

### 4. ANALYSIS AND DISCUSSION

A field survey was conducted for the selected sample through a customized questionnaire form that included recording data about commercial uses in terms of the type, number, and area of commercial activities, as well as determining the number of vehicles frequenting the commercial area according to the type of commercial activity. Data was collected for (119) various commercial units that included (4) restaurants and cafeterias, (17) specialized stores, (7) pharmacies, (15) medical clinics, (3) gyms, (7) markets, (22) offices, with a total building area of (6674) square meters, as shown in Table 1. General indicators of the commercial units in the study area and Table 1 show the field survey for the study area:

#### 4.1 The relationship of the type and area of the commercial unit to the number of vehicles that frequent daily

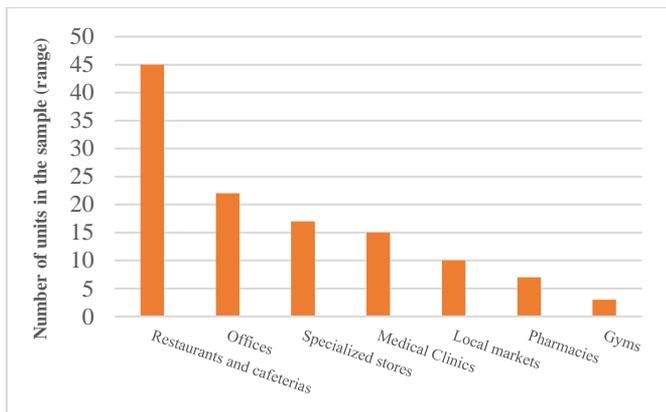
The flow of vehicles was monitored in the study area and it

was found that there were (1895) vehicles parked for purposes related to the studied commercial units. The results showed that there was a direct correlation between the number and type of commercial units and the number of frequent vehicles.

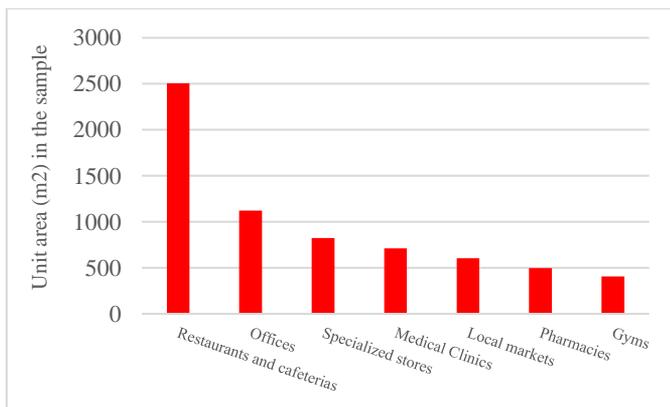
Frequency of vehicles in restaurants and cafeterias, while other types of commercial units show less traffic flow, as shown in Figures 2 and 3.

**Table 1.** The results of the field survey of the general indicators of the commercial units in the study area

Type of Commercial Unit (Building)	Number of Units in the Sample (Range)	Units of Area (m <sup>2</sup> ) in the Sample	The Number of Frequented Vehicles during the Day	Average Vehicle Downtime (min)	The Number of Vehicles Parked in the Street Irregularly	Average Duration of Daily Activity (hours)
Restaurants and cafeterias	45	2506	807	120	403	16
Offices	22	1122	353	30	102	6
Specialized stores	17	823	244	30	83	8
Medical Clinics	15	712	198	45	63	8
Local markets	10	605	143	30	52	10
Pharmacies	7	498	97	15	39	10
Gyms	3	408	53	60	25	10
<b>Total</b>	<b>119</b>	<b>6674</b>	<b>1895</b>		<b>767</b>	
<b>Average</b>				<b>47</b>		<b>10</b>



**Figure 2.** Number of vehicles frequented daily in the sample concerning the type of commercial use

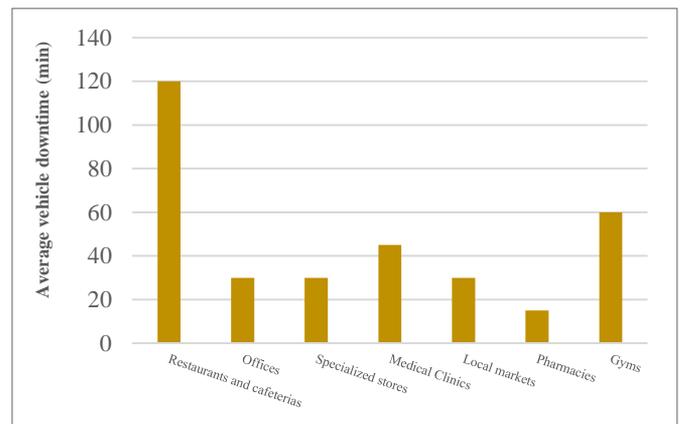


**Figure 3.** The number of daily frequented vehicles in the sample concerning the area of commercial use

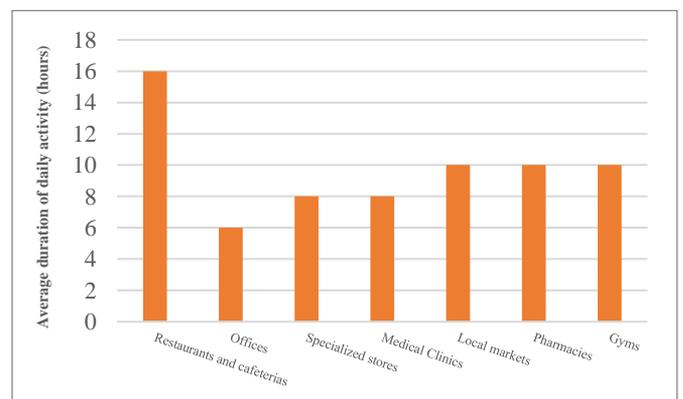
#### 4.2 The relationship between the type of commercial unit and the average vehicle downtime

The results showed a discrepancy between the type of commercial unit and the stopping period of vehicles heading to it, as it was found that pharmacies require an average parking period of approximately (15) minutes, while local markets, specialized stores, and offices require a parking

period of approximately (30) minutes, and clinics require an average parking period of (45). Minutes, restaurants and cafeterias appear as the most commercial type that requires a long parking period, as the results of the survey showed that vehicles heading to parking for restaurants and cafeterias for an average of (120) minutes, which explains the large crowds in the study area, as shown in Figure 4.



**Figure 4.** Average vehicle downtime (minutes) concerning the type of commercial use



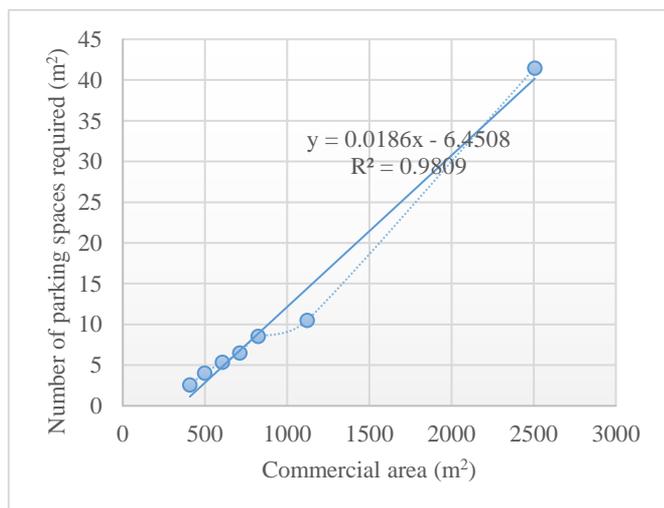
**Figure 5.** The average duration of daily activity (hour) concerning the type of commercial use

### 4.3 The relationship of the type of commercial unit to the average duration of daily activity (hours)

The results showed that there is a discrepancy between the type of commercial unit and the average duration of daily activity in it, as it was found that the offices practice a daily work activity of up to (6) hours, followed by medical clinics and specialized stores with a daily work activity of up to (8) hours, and gyms, markets and pharmacies with a daily work activity of up to (10) hours. While restaurants and cafeterias appear as the most commercial types that average duration of daily activity, the results of the survey showed that the longest activity period was monitored in the study area, with an average of (16) hours, which explains the large number of crowds in the study area, as shown in Figure 5.

Data analysis of the study area showed that the commercial activity created in the residential neighborhoods (by changing residential use to commercial) has increased traffic and the flow of vehicles, which led to severe congestion in the area. This traffic is related to the nature of the activities of commercial units, especially restaurants and cafeterias, and because of the lack of sufficient parking lots in the area, the problem will become increasingly exacerbated. Theoretically, and according to the results of the field study, it is possible to predict the need for parking lots according to the nature of the commercial activity, or try to describe the quantitative behavior of the effect of the area of the commercial area on the number of vehicles frequenting the study area, and thus estimate the need for parking spaces in the commercial area. From Table 1.

It can be noted that the number of vehicles parked irregularly is related to the nature of the activity of the commercial units and their areas and the average duration of the daily activity of the commercial unit, which the results indicated as a general rate for the study area of about (10) hours per day, and when representing the results graphically for the number Irregularly parked vehicles (and therefore the need for vehicle parking) Concerning the area of commercial units, it can be concluded that the larger the area of the commercial unit and the duration of its daily activity, the greater the number of vehicles parked irregularly or the need for vehicle parking, as shown in Figure 6:



**Figure 6.** The number of vehicles parking required according to the commercial space in the area

It appears from Figure 6 above that the number of required

vehicle parking spaces is directly related to the area's commercial area. The above relationship curve shows a linear behavior with a confidence rate of (98%), which can be described by the equation below:

$$Y=0.0186x-6.4508 \quad (1)$$

whereas: Y: the number of car parks required.

X: The area of the commercial units (sqm).

Depending on the above model, and to reach an estimation criterion for the number of vehicle parking spaces required concerning the commercial area, Table 2 shows a set of estimates for the required vehicle parking spaces concerning the area of commercial use.

**Table 2.** The number of vehicle parking spaces required concerning the area of commercial use

Commercial Area (m²)	No. of Required Parking	Required Area for Parking (m²)	The Percentage of Commercial Use Space (%)
500	3	75	15%
1,000	13	325	33%
1,500	22	550	37%
2,000	31	775	39%
2,500	41	1,025	41%
3,000	50	1,250	42%
3,500	59	1,475	42%
4,000	68	1,700	43%
4,500	78	1,950	43%
5,000	87	2,175	44%
5,500	96	2,400	44%
6,000	106	2,650	44%
6,500	115	2,875	44%
7,000	124	3,100	44%

According to Table 2 above, a discussion of the results of the field study and modeling appears, including:

1. When the commercial area is around (500 m²), the need for vehicle parking is relatively limited and amounts to (3) vehicles, and considering the criterion for providing parking space for vehicles of (25 m²), the area of the vehicle parking space is equal to (75 m²) or equivalent to (15%) of the commercial use area, such a case seems to be widely applicable for commercial facilities of relatively fast demand (short time facilities) such as pharmacies, small shops, some types of offices (small companies) and small showrooms, were costumers seem to spend about (15-30) minutes in such facilities.

2. When the commercial area begins to increase within the limits of (1000-2000 m²), the need for parking spaces changes to a greater extent. The commercial area is within the limits of (1000 m²), necessitating the need to provide (13) vehicles, i.e., more than four times the need, compared to an area of (500 m²). meters described in the first issue above. This case indicates the need for a larger space for car parking compared to the area for commercial use, and it ranges between (33%-39%), such a case is found in facilities of medical clinics where patients spend about (45-60) minutes in such facilities.

3. If the area of commercial use exceeds (2000 m²), the change in the need for parking lots will be greater, as the percentage of the required parking space can reach up to (44%), such a case is mainly founded in restaurants and cafes where costumers spend the longest time, about (120) minutes.

4. From the above three points, it is clear that it is possible

to classify the need for vehicle parking according to three categories:

A. A commercial area (1000 m<sup>2</sup>) or less, of which (24%) must be allocated as parking lots or (10) parking lots / 1000 m<sup>2</sup>.

B. A commercial area (1001-2000 m<sup>2</sup>) needs to be allocated (35%) of it as vehicle parking or (14) vehicle parking / 1000 m<sup>2</sup>.

C. Commercial area (2001-7000 m<sup>2</sup>), of which 43% of it needs to be allocated as parking lots or (17) parking lots / 1000 m<sup>2</sup>.

## 5. CONCLUSION

A field study was conducted in the city of Baghdad for an urban area in which the land uses shifted unplanned and randomly from residential to commercial use, which led to an increase in the flow of vehicles to the area and consequently large traffic congestion in it due to the lack of parking lots that can accommodate the parking needs of vehicles. The reason for the congestion of the streets in the study area is the parking of vehicles in the street section in violation of traffic rules due to the lack of vehicle parking in the area. Commercial land uses differ in their need for parking lots, as the study showed that restaurants and cafeterias are the most in need of parking lots, due to the relatively long stopping period of vehicles heading to them. While the need for vehicle parking is directly related to the area of commercial use, at a rate ranging between (10-17) vehicle parking / (1000 m<sup>2</sup>) of commercial use. On the other hand, restaurants and cafeterias need to provide parking spaces at a greater rate, with a limit of (20) parking spaces / (1000 m<sup>2</sup>). In conclusion, parking lots need to provide an area of (24%-43%) of the commercial use area in the study to avoid traffic congestion. When comparing parking estimations findings of this research vs. local municipality requirements, there is a wide gap, local municipality requirements (belongs to the 1970's) stated the need for (1) parking lot for every (3) meters of the building façade in the main street, for example, a building with a façade width of (12) meters will have (4) parking spaces despite of building floor count, building area or type of facility. Parking demand estimations for the studied area, if practically applied, will have a positive impact on vehicular traffic solutions. The simplicity of the linear regression model obtained seems to describe estimations of vehicle parking needs clearly, with a coefficient of R<sup>2</sup>=0.9809.

It's widely important to consider the need for vehicular parking in land use, there is a need for re-assessing vehicular parking demand at all levels of urban sectors, and urban policies should adopt the construction of vehicular parking projects and smart systems. further studies are needed on the types of parking projects such as multi-level parking, automated parking, and smart parking management systems.

According to the foregoing, the article recommends conducting design and planning studies to re-employ the area and organize the parking movement of vehicles, as well as the impact of people's movement if the area is re-coordinated to encourage the movement of pedestrians and bicycles...etc. It may be recommended in the future to develop the model by taking more variables and summarizing them using the factor analysis method to come up with the most influential factors among the economic factors or social factors...etc.

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