Developing a Relationship Between Land Use and Parking Demand for The Center of The Holy City of Karbala

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Abstract:

Car parking generation considers as the main parameter for estimating the car parking demand. However, developing a relation to correlate such demand with car parking generation is in high demand for any city, where such relation, of course, different from city to city. In this paper, the relation between the car parking demand and land use have been determined for the center of the holy city of Karbala. Whereas, the land uses were designated into: residential, heritage, commercial, educational, governmental, public, religious and health. Then, the demand was determine from a representative sample for each land use facility. Moreover, additional date were collected for the visitors whom used the current car parking at AM, and PM periods and at peak hours for a normal day. Form such vital data, a model of a relation between the type of land use and car parking generation have been established. Such relation can be a vital element of the highway mode of the transportation network in the city Karbala.

Keywords: city of Karbala, generation, Land use, parking, Transportation .

الخلاصة

تعتبر مولدات مواقف السيارات العنصر الاساسي في تحديد الطلب على مواقف السيارات. و عليه هناك حاجة ملحة لتطوير علاقة تربط الطلب مع مولدات مواقف السيارات لاي مدينة، وهذه العلاقة بالطبع تختلف من مدينة الى اخرى. وفي هذا البحث ، تم تطوير علاقة بين الطلب على مواقف السيارات و استخدامات الارض لمركز مدينة كربلاء. حيث تم تصنيف استخدامات الاراضي الى سكني و تراثي و تجاري و تعليمي و حكومي و عام و ديني وصحي. ثم تم احتساب الطلب لكل نوع استخدام من خلال عينة تمثيلية. بالاضافة لذلك، تم جمع بيانات اخرى من المواقف الحالية التي يستخدمها الزائرون؛ صباحا، مساءا, وخلال اوقات الذروة في يوم عادي. ومن خلال البيانات المجمعة تم وضع نموذج للعلاقة بين نوع استخدام الأراضي والطلب على وقوف السيارات. ومثل هكذا علاقة تعتبر عنصر حيوي لشبكة النقل في مدينة كربلاء المقدسة.

الكلمات المفتاحية:– مدينة كربلاء، استخدام الاراض ،مواقف السيارات، توليد الرحلات، المواصلات .

Introduction

To determine the number of car parking for each land use, it is required to know the parking generation for all land uses, as well as, specifying the size of traffic flow in highway network. Subsequently, all the demand car parking can estimate easily if the relation between demand of car parking and land use is available. Consequently, the estimated car parking demand is help in improving the highway network activities, if the required car parking is prepared. Whereas, disproportion between parking demand and available car parking on street, led to street congestion; car seeking for parking will occupy the street for additional time. On other side, erecting off-street parking makes another problem related with economic; generally off-street car parking is much expensive from on-street car parking. Nevertheless, off-street car parking is facilitated best level of serves to the street. Basically, determining the parking generation for each land use gives good control and manage for highway network that related with. Accordingly, marginal distribution for cars in highway network will prevent. On the other side, the good estimation of the numbers of car parking for each land use assists the engineers and planners for establishing best choice to develop urban area, because the number of car parking can consider as the main character in street network.

Current urban planning of the Center of the Holy City Karbala (CHCK) severs from many problems, whereas congestion is one of the main problem. Congestion in one of its face, a problem results from searching for parking, as mentioned previously.

However, none of the previous urban studies for CHCK has taken such problem seriously; in other words, acknowledge that the parking generation for each type of land use can affect the real number of traffic volume. Obviously, each land use generates different parking demand; as example, the residential land use differs from commercial land use in the number of car parking generation. Furthermore, the same land use for different cities reveals differ parking generations, whereas the CHCK not an exemption. It is more complicated, as it is consider as a unique religious city, where its visitors are not commuters, almost they are come in specific time of the day, week, or year, and their requirements for parking are not traditional. Therefore, known visitors traveling modes and characteristics with available land use properties, are facilitated the engineering and planning decisions.

Generally, the land uses in the CHCK were divided into eight land use; namely, residential, heritage, commercial, educational, governmental, public, religious, and health, as can be seen in Figure 1, which is explained the study area with different land uses. Such designation has been achieved according to the survey has been conducted by specialized groups under the supervision of the Ministry of Municipalities and Public Works. The survey was conducted for the re-design of the master plan for the CHCK (Dewan, 2011). Moreover, the survey displayed many other information, like the percentage of each land use type, as can be seen in Table 1.

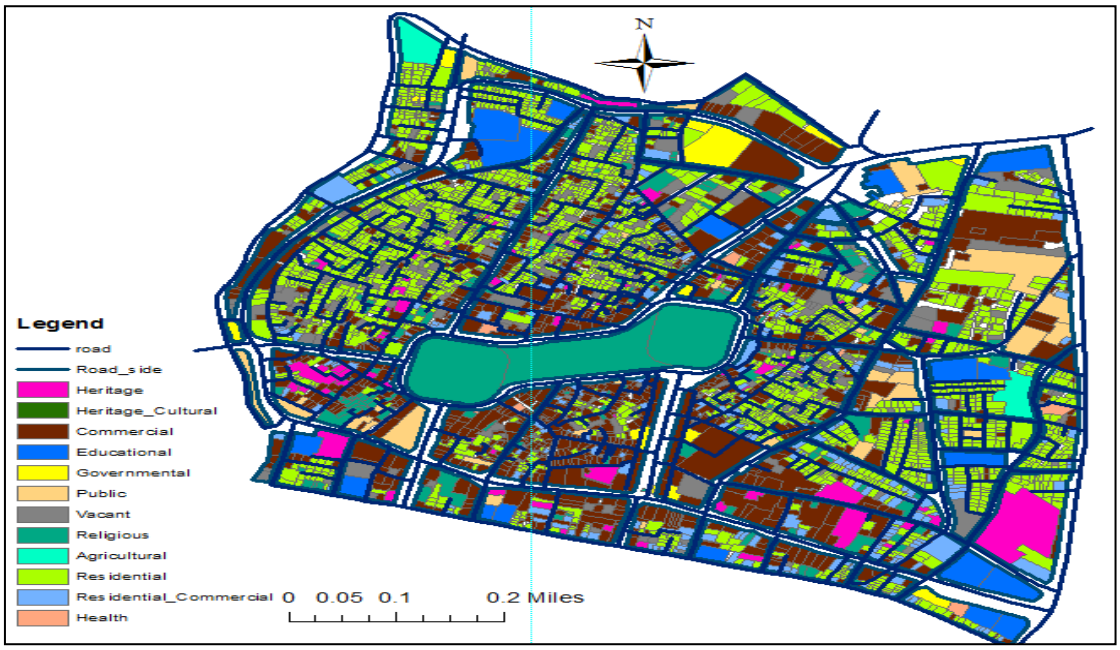

Figure 1: land uses for the Center of the Holy City of Karbala, (Dewan, 2011)

In this research, the relations between land uses and car parking demand have been established, toward put simple base for the CHCK to identify the required real number for parking generation and car parking demand, which can increase the activity of the current transportation network.

Table 1 information for each alter land use in the CHCK

Type of land use	Area	percentage	Number of building
Residential	296767.135	56%	2547
Commercial	204488.58	24%	1089
Vacant	70936.12	7.43%	336
Religious	66372.8494	4.44%	201
Public	52443.76	0.93%	42
Governmental	18554.4356	0.40%	18
Educational	44769.972	0.35%	16
Health	2059.1485	0.15%	7

Literature Review

Generally, the,4th,edition of Parking Generation Manual of the Institute of Transportation Engineers (ITE) comprises about sixty nine land use classifications; it signified a group of data since 1978(Institute of Transportation Engineers, 2010). From poor to good, statistics of land use characters are ranging the Parking generation for numerous levels. For example, when parking demand identify by the Gross Floor Area (GFA), it produces great coefficient of determination; equally, when number of employees is used, it products small coefficient of determination. In addition, the ITE suggested that the identical data sets or small data sets, can produce low coefficient of determination, consequently unreliable relationship (Institute of Transportation Engineers, 2010). The Institute of Transportation Engineers (2010), also, highlight a guidance and information for site selection, consents procedure, background, and independent variables. For example, parking generation for residential land uses is correlated in relations of dwelling units, persons, vehicles, and areas as independent variables. Another example is the office land uses, which is expressed in relation of employees and area.

In another study, Douglass (2011) conducted a research study to figure the New Zealand, Australia, USA, and UK data on trip and parking relations to land uses, he investigated trip generation survey and information guides from the mentioned countries. The study successfully figured seasonal traffic and parking differences, and determined the practical parking design demand for a whole year as the 85th percentile consummation, which is correspondingly the 50th highest hour. Moreover, Independent variables such as GFA, gross leasable ground area (which is represented 80% of the GFA), site area, employees, and action units were determined from survey processing. The study concluded that the best practical unit for wide district plans is still spaces per 100 m^2 of the GFA (Douglass, 2011). Regidor (2010) measured in Philippine some issues on local trip and parking rates. Parking generation in Philippines used a number of applicable regulations on the facilities of off-street parking for different types of developments, where, the National Building Code of Theo State of the Philippines is one of these regulation. The study concluded that there is numerous limitations for parking requirements for such development character; such as GFA, gross profitable area, floor area ratio (density), parking slit cost, and distance from the CBD.

The Australian Roads and Traffic Authority, (2002) drawn a guide that demonstrate various effects of traffic generation on development. This guide shows that different parking demands could occur at a specific site, which may influence on transport policy and travel strategies. The parking facilities recommended, as much as possible, on physical features of the suggested development, principally the GFA.

The Department of Transport of Abu Dhabi issued a manual for estimating the parking and trip generation rates for some local land uses, through the survey on nearly 400 different sites around the UAE; parking generation rates included all kinds of dominated land uses in Abu Dhabi. The manual covered places in the UAE, namely, Abu DhabiCity, Al-Ein City, and others for CBD and non-CBD areas (Department of Transport of Abu Dhabi, 2012).

Al-Masaeid *et.al.*,(1999) established arithmetical relationships for predicting vehicle parking demands for different land uses in some cities in Jordan. He studied 53 hospitals, 40 hotels, 42 office buildings, 35 apartment buildings, 21 restaurants, and 17 shopping centers (for a total of 208 sites). Within his collection process, the survey limited with three criteria. The First, studied site had specific parking lot, which used by the site commuters only. Second, studied sites located in dissimilar cities. Third, the parking lot should have a appropriate parking supply. Moreover, all

the selected sites were in separate CBD's. However, he concluded that the exponential models are acceptable for representing the collected data, except for restaurants and shopping centers where the linear models are representative. The researchers found that in contrast to developed countries, the parking demands for the examined land uses in Jordan had worse rates. Al-Sahili (2010) conducted parking and traffic counts adjoining to residential, hotel, office, and shopping/retail center land uses to internment trips and parking associated with the specific land use. Eleven land uses were surveyed during the AM peak and PM peak periods for normal day. Where models were established to represent the relation of these land uses with each parking generation demand.

From the previous study, it can concluded that GFA could be a vital independent variable to estimate the land uses parking demand. thus in this study a detailed survey conducted at Am and Pm period to collect the required data to establish a relationship that correlate land uses demand by the GFA for the CHCK.

Research Methodology

The main steps in this research is identified the representative data, therefore, determine the car parking demand for each land use, subsequently, relationship have putted for each land use between the car parking demand and land use type. However, the first step in the methodology of this paper is the collection of data. There were many related parameters for data collection for getting the relationship between the car parking demand and land use; namely, type of land use, period of collected data, sample size, equation of estimation, and determined reliability for each equation of estimation.

Land uses for the CHCK demonstrated formerly in Figure 1; namely, residential, heritage, commercial, educational, governmental, public, religious, and health. Each of subdivision land uses designated according to its related general group of land use, as example, the supermarket and center of shopping considered as commercial land use, while each house, and apartment considered as residential land use, hospital consider as Health land use, school consider as educational land use, governmental office consider as governmental land use, and so on. Religious land uses demand, which are mainly represent the demand of the holy shrines of Imam Hussein and Abbas were determined from both generation of visitors and employees. All these land uses classified identically according Dewan designation (Dewan, 2011).

Furthermore, representative samples for each land use were specified to collect the required data (the demand for each sample within different periods), which are presented in Table 2. This table shows the demand for three periods; namely, AM, PM and peak hour. These land uses demand were placed in CBD urban areas, and isolated from overlying activities with different land uses.

Table 2: Car-parking demand for different land use and different periods

Type of land use	Sample size	Area(m^2)	Parking demands(AM)	Parking demand(PM)	Max. parking
Heritage	30	45-1963	4-157	7-160	7-160
Commercial	34	42-879	1-18	2-20	2-20
Educational	31	130-6193	4-186	6-186	6-186
Governmental	28	79-7286	2-219	1-210	2-219
Public	28	44-1564	1-47	2-50	2-50
Vacant	29	48-2397	2-72	2-72	2-72
Religious	30	48-19904	7-1990	7-1990	7-1990
Residential	28	55-1464	1-15	1-15	1-15
Health	30	39-1069	6-178	6-178	6-178

In other hand, the collected sample size were dependent on McCourt suggestion (McCourt, 2004); to establish regression model, the sample size not less than four land use, whereas each land use was take to determine the regression model. Any traveling vehicle on road or street will park for specific time with either long or short time of parking (Garber, 2010). Thus, the collected data at different time (i.e., AM, PM, and at peach hour time) toke this in the account, where the average vehicles standing time for each car park was determined.

Then, different equations were tried to represent the more appropriate relationship between the parking demand and GFA for each land use. These equations as shown below

$P = \beta . X + Z \quad (linear) \ldots\ldots\ldots\ldots (1)$

$P = \beta . X^C \quad (power) \ldots\ldots\ldots\ldots\ldots (2)$

$P = \beta . e^C \quad (exponatail) \ldots\ldots\ldots (3)$

$P = \beta . \ln X + C \quad (logarithmic) \ldots\ldots (4)$

Where:

P: number of space for demand of parking

$X: indepene\ value$

$\beta: slop$

$Z, C: constants$

For each type of land use independent value were specified. For example, for the commercial land use, the total area was specified. For governmental land use; the total area and number of employment were specified, but the number of employment didn't give real value, so the total area was adopted as the independent value. Institute of Transportation Engineers (2010)suggested the regression which use one independent variable, there models were evolved by using simple linear regression. Subsequently, the equation were gotten have been used in GIS (geographical information system) to explain distributed of car parking demand in study area as in Figure 2.

The coefficient of determination, R^2, was adopted to express the best regression model. More specifically, the adjusted R^2 was used to alter the value of R^2. It is normally used for small sample sizes where the estimated coefficient of determination gives higher values than that of the actual coefficient. The adjusted R^2 should be adopted when its value differs significantly from the value of R^2 (Green, 2010). The variation in the percentage number of parked vehicles with regard to the alteration in the sample size of independent variable is defined by R^2 (McCourt, 2004). The precision of the developed model or rate of prediction was accomplished by the means of numerical tests.

Estimating Models

The demand for each type of altered land use has been collected for representative samples. The numbers that have been gotten from the questionnaires as shown in Table 2. From Table 1, the size of each land use type in CHCK was identified; area of the whole land use with different type, percentage for each land use according to total area, finally, number of building for each land use. Consequently, the total demand for each land use can be determined, furthermore the total demand in specific area or sector can be determined too, as can be seen in Figure 2.

In each parking, data collected within two days, correspondingly, in each day of two periods AM and PM counting were achieved. Table 2 explains the data that were collected in different period, consequently, the data were collected represent the average value for two days.

From the data which were collected, models have been developed for each land use as can be seen in Table 3. The reliability equation for each land use; simple linear regression, exponential regression, Logarithmic regression and power regression have been tried. Where, the regression models with R^2 have been determined, consequently, land use for each 100 square meter is correlated to demand using four model. In other words, the rate between the area of land use and the car parking demand has been collected. For each simple regression the reliability have determined, therefore check the reliability to be not less than 0.6 (Shacham, 1996). Then the regression model with higher R^2 was adopted for each land use, as can be seen in Table 4.

Table 3 developing four model for each type of land use

Type of land use	Type of equation	Model	R2
Heritage	Linear	$y = 0.0634x + 4.9845$	0.9639
	exponential	$y = 12.887e^{0.0011x}$	0.7327
	Logarithmic	$y = 37.34\ln(x) - 172.39$	0.7549
	power	$y = 0.1707x^{0.8723}$	0.9611
Commercial	Linear	$y = 0.0075x + 0.4456$	0.6996
	exponential	$y = 0.6809e^{0.0052x}$	0.6996
	Logarithmic	$y = 0.8734\ln(x) - 2.7479$	0.6574
	power	$y = 0.0744x^{0.6054}$	0.6574
Educational	Linear	$y = 0.0262x + 0.84$	0.9443
	exponential	$y = 15.605e^{0.0005x}$	0.8012
	Logarithmic	$y = 39.584\ln(x) - 230.5$	0.7065
	power	$y = 0.0631x^{0.8883}$	0.9607
Governmental	Linear	$y = 0.0199x + 6.4622$	0.9379
	exponential	$y = 11.365e^{0.0004x}$	0.5985
	Logarithmic	$y = 22.486\ln(x) - 113.5$	0.5727
	power	$y = 0.2462x^{0.6802}$	0.8118
Public	Linear	$y = 0.0195x + 3.3419$	0.6209
	exponential	$y = 4.402e^{0.0015x}$	0.4985
	Logarithmic	$y = 8.3367\ln(x) - 35.351$	0.4214
	power	$y = 0.1595x^{0.6946}$	0.503
Vacant	Linear	$y = 0.0173x + 4.4116$	0.7494
	exponential	$y = 4.6005e^{0.0012x}$	0.3623
	Logarithmic	$y = 8.0227\ln(x) - 31.57$	0.641
	power	$y = 0.1587x^{0.724}$	0.5667
Religious	Linear	$y = 0.072x + 2.946$	0.9494
	exponential	$y = 8.0064e^{0.002x}$	0.5657
	Logarithmic	$y = 26.926\ln(x) - 115.68$	0.7752
	power	$y = 0.0845x^{0.9983}$	0.8038
Residential	Linear	$y = 0.0057x + 0.4503$	0.9333
	exponential	$y = 0.9303e^{0.0016x}$	0.7247
	Logarithmic	$y = 1.7988\ln(x) - 7.2762$	0.5957
	power	$y = 0.0867x^{0.5454}$	0.5687
Health	Linear	$y = 0.1146x - 14.27$	0.6406
	exponential	$y = 7.6522e^{0.0024}$	0.7925
	Logarithmic	$y = 26.249\ln(x) - 106$	0.3541
	power	$y = 0.5596x^{0.6675}$	0.6594

Table 4 equation with higher coffecient of determination

Type of land use	Model with high regression	Number of car parking
Heritage	Linear y = 0.0634x + 4.9845	For each 100 m² equal to 8
Commercial	Linear y = 0.0075x + 0.4456	For each 100 m² equal to 2
Educational	Linear y = 0.0262x + 0.84	For each 100 m² equal to 1
Governmental	Linear y = 0.0199x + 6.4622	For each 100 m² equal to 3
Public	Linear y = 0.0195x + 3.3419	For each 100 m² equal to 2
Vacant	Linear y = 0.0173x + 4.4116	For each 100 m² equal to 1
Religious	Linear y = 0.072x + 2.946	For each 100 m² equal to 8
Residential	Linear y = 0.0057x + 0.4503	For each 1000 m² equal to 2
Health	Exponential y = 7.6522e0.0024	For each 100 m² equal to 6

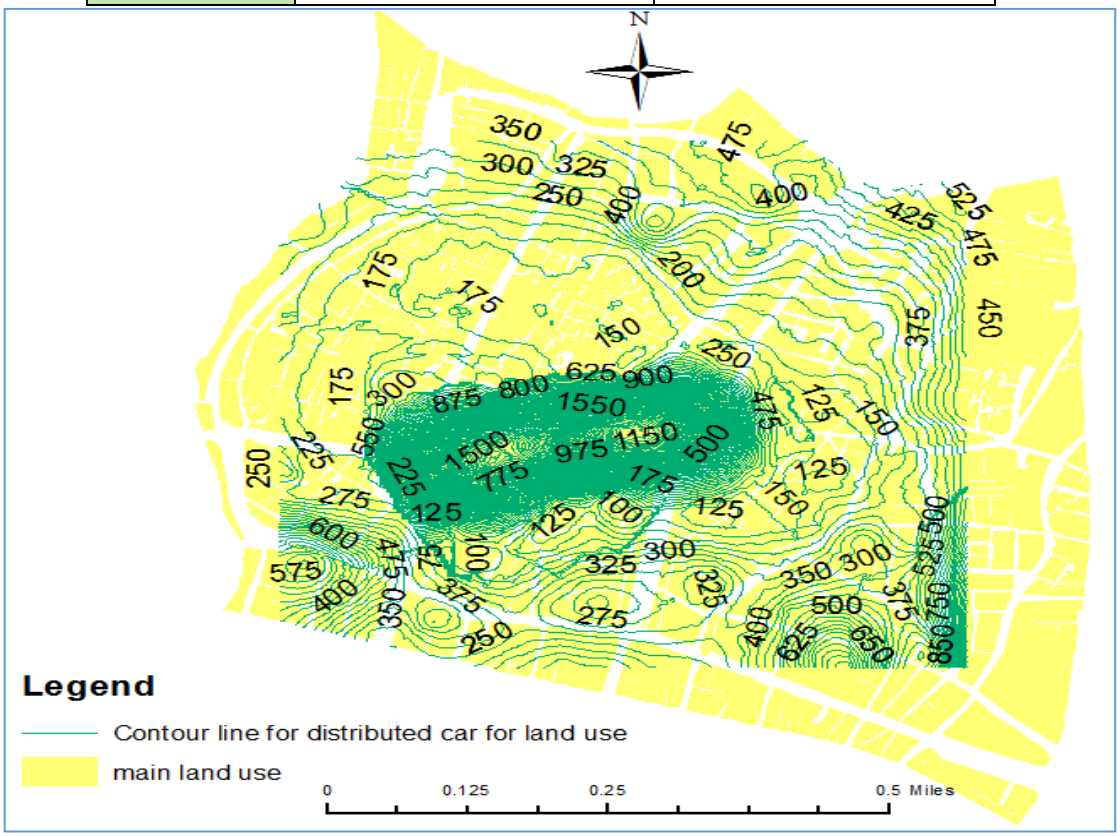

Figure 2: distribution for car parking demand in the Center of the Holy City of Karbala

Conclusions

From the data collection and analysis process for the car parking characteristics of the CHCK, the following can be concluded:

1. For car parking demand eight land uses in the CHCK can be identified; namely, commercial, vacant, religious, public, governmental, educational and health. Where, the number of car parking space for each type land use was found significantly varies on other types.
2. The simple linear equations are found to be representative for most land uses demand with good reliability, the only exemption is the health land use where the exponential model shows higher coefficient of determination.
3. Almost the car parking demand is concentrated around the holy shrines of Imam Hussein and Abbas.

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