

Public Parking Topology in Urban Spaces Using GIS (Case Study: Paveh City)

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ABSTRACT: This study is addressing public parking topology in urban space (Paveh city) using Fuzzy logic and hierarchical analytic model (AHP) in GIS environment. This study method is applied in terms of study objective and it is analytic- descriptive in terms of study framework. Data collection was conducted through field- desk and using questionnaire with volume of 400 people and interviewing experts and seven criteria are considered that are 1.Gradient, 2. Population density, 3.Distance of available parking lots from urban passages network 5. Building quality (uncultivated lands and buildings with low quality) 6. Distance from travel absorption center (business centers and main shopping center, educational centers, administrative centers, cultural centers, health care centers and Hospitals), 7.The property value that is used as a key indicator for parking topology in the studied area. The use of weighting techniques and assigning points and combining data, analytic hierarchy AHP in fuzzy logic bed and overlap methods of indices are leading properties of this research. The findings of this study led to zoning under study limitations in five classes of suitable, fairly suitable, indifferent, rather inappropriate and inappropriate. The results showed that suitable areas for the construction of parking areas in Paveh city does not include current locations, which reflects the disproportionate distribution of this usage with the standard calculated per capita and shortage of parking area of 15,872 square meters and current location is not only responsive to urban traffic congestion, but also it is not constructed in the right place. And about 24.1 percent of the total urban area that is 54.6829 hectares, is suitable land (based on uncultivated land and low quality buildings), if attracting private land owners consent and coordination with municipality and cooperation with officials in order to construct the parking that shows the final map of topology model of appropriate areas to make public parking areas in different parts of the city.

Keywords: topology, public Parking, Geographical Information System (GIS), Analysis hierarchical process (AHP), fuzzy logic, Paveh city.

INTRODUCTION

Regarding rapid urbanization in recent decades and increasing the number of motor vehicles, traffic in the street became a problem in many cities. On one hand, transportation in the Passages impressed all activities of citizens; so one of intellectual concerns of urban managers is solving traffic problems in cities. To smooth vehicle movement and solving the problem of traffic, many measures such as the construction of urban transport infrastructure like communication routes, underpass and overpass, squares and also development of public transport such as subway, city buses are done by city managers. In this line, the construction of several public parking in proximity to urban streets is one of effective measures in reducing traffic in order to long term parking beside streets. Topology and making different urban usages like public parking are among fundamental needs of many cities, which are done in line with citizens' peace and welfare and solving city problems. If this activity was done with no attention to effect and mutual effects among usages it will not only reduce current problems, but also it will make a lot of problems and difficulties itself, so it is necessary to study all related factors with under question problem (Qazi Askari Naieni, 2004, p. 3).

One of most effective parameters of making parking is its location. Inappropriateness of parking location and their non-normative dispersion lead to not only ineffectiveness of this parking, but also it causes to more urban traffic and consequently more accidents, more time, distance of intercity travels, increasing gas consumption, air pollution and increasing sound pollution (Qazi Asgar Naieine: 2004: p.38). Therefore, it is necessary to use new system in parking topology that is able to analyze a lot of parameters simultaneously. One of these systems is GIS system. Today, this system capability is used in topology in different contexts (Shadie: 2004: p. 12). Paveh city is considered as a high city in Kermanshah province that parking shortage is seen in it. This city, due to topography situation of this city, has mountainous landscape that consists of mountains and hills that most land areas of this city has a gradient more than 15 to 20 percent, and it has limitation and shortage for land. Among disorganization reasons of current parking situation in this city, inappropriate topology, non logic distribution of parking lots, no balance between population and parking usage per capita and lack of necessary and enough parking lots in city area, as well as traffic resulted from poor passage network, passages with narrow width, poor public transportation system, lack of traveling taxies in the city, expensive price and limitation of land, traditional contexts existence and non applicability of current plans in passages due to high cost of these plans, travel absorption usages in main centers of this like business centers and services centers including drugstores and physicians offices can be referred. Also, lack of parking, inappropriate topology of this usage and related problems like automobiles margin stop, personal automobiles transportation, lack of an appropriate servicing, limitation of entrance routes in this city will make traffic a very hard problem. We see cars traffic in this city because of lack of parking lots in axis and main streets of this city like 26 Mordad Street, Islamic Revolution Street and Imam Khomeinie Street, as traditional method is used in designing and construction, so logic usage does not happen for expensive and rare streets. For traffic smoothness and reducing traffic problems of Paveh city, also organizing space system of the city and consequently citizen satisfaction, public parking lots should make in an appropriate place and it should logically distributed in the city. Therefore, we tried in this study to solve urban transportation problems such as public parking optimization topology and also offer guidelines for reducing urban traffic congestion by studying current situation and reviewing Paveh city usages including parking usage by determining criteria and effective and important factors in parking optimized topology and using geographical information system GIS (analysis hierarchical model AHP and fuzzy logic).

Study background

Among works that are done in this field, we can refer to Weant studies (Weant: 1978) in terms of topology for parking lots location. His studies about requirement of some American cities for new parking lots were conducted using GIS. Roberte (Roberte: 1987) studied during decades of 1960- 1990 in field of using GIS ability in urban services centers topology especially parking and also studies about need of some American cities to new parking lots using GIS. In Iran, during recent years, usages topology discussion in the GIS environment and also using AHP and fuzzy methods are considered and welcomed by most of researchers. Talebie (2010), in a study entitled optimized topology for multi- floors parking in Tehran using AHP method, AHP Nine Degree and FUZZY method, studied multi- floor parking topology in seventh region in Tehran city. Shahabie and Barzegar (2011) also, in a research, evaluated and measured grade and AHP methods in parking lots topology in 15th region in Tehran, after reviewing four scenarios, they were divided into four classes of high, medium and low desirability and finally by using weighting method, they select the most appropriate option.

Study hypotheses

- 1- It seems that people are not satisfied by parking lots quality and quantity.
 - 2- It seems that effective factors in controlling traffic of Paveh city are not used appropriately.
- It seems that parking lots are not located appropriately in Paveh city.

MATERIALS AND METHODS

Based on objective, this study is applied. And this study has analytic- descriptive nature in terms of method framework. Measurement tools in this study are questionnaire and software GIS, this study is a field study and collecting data are done as field, desk, and Internet and interviewing experts in this context. Using data collection and studying desirable limitation and by reviewing parking current situation in Paveh city, required parking space was estimated and then hypotheses were proved by the use of questionnaire and related software SPSS and the effective criteria and parameters were determined in parking topology including 1- gradient (Qazie Asgarie: 2004: p. 105) 2- population congestion (Ebadie: 2007: p 52-54) 3- distance of current parking lots from travel absorption centers (Zareh Pische: 2011: p. 8) 4- distance from urban passages (Shahie: 2003: p. 25-30) 5- building quality (uncultivated

lands and low quality buildings) (Metkan: 207: w. 210) 6- distance from travel absorption center (business centers and main shopping centers, training centers, administration centers, cultural centers, health care centers and hospitals (Qazie Asgarie: 2004: p. 106) 7- property value (Richard, 2001: 31); a database from any layer was formed and indices space analysis was done and then using AHP analytic method, parameters were weighted and utilizing fuzzy logic model (reviewing desirability of any class for any sub criteria based on fuzzy model) and using linear membership function, desired layers were valued and finally a map of public parking of desirable location was obtained by valued layers overlap method. In this study, statistical population is Paveh citizens and its sampling method is random that common methods like Cochran formula was used to estimate sample size, based on which due to statistical population of Paveh city that includes 20885 people, random statistical population sample size is 400 people:

$$n = \frac{\frac{z^2 pq}{d^2}}{1 + \frac{1}{N} \left(\frac{z^2 pq}{d^2} - 1 \right)}$$

Analytic hierarchy process (AHP)

In AHP method, mutual comparison method is used. For doing this, in first stage, at first all reviewed criteria are compared and relative importance amount of any couple get point from 1 to 9 and they were entered into a matrix, they are compared mutually and weight of each of them will be clear by comparing with others, then in second stage, all measures are weighted by normalizing method. In third stage, by having measures weight and alternatives point, combination weight of each site is obtained via measures weight times by alternatives point and sites are surfaced by weight order and final stage is adjustment determination that is in analyzer view (Husseini: 2000: p 76). Certainly, analytic hierarchical process is one of the most comprehensive systems designed for decision making by multiple measures because this technique provide formulization of this problem as hierarchical and also it has the possibility of considering different quality and quantity indices in this problem (Dyer & Forman, 1992).

Table 1. measures couple matrix

Point (preference intensity)	Description
Equally referred	1
Moderately referred	3
Strongly referred	5
Very Strongly referred	7
Extremely referred	9
Half-way referred (when there are middle states)	8, 6, 4, 2

(Adaption: a sample of couple comparison matrix (Zebardast: 2001: p 11)

Fuzzy logic method

In fuzzy logic, each class take a member that shows its desirability and each layer is rated in a comparison between zero and one, that is 1 is the most desirability and zero has no desirability and there are a range of these amounts between these two numbers that whatever they close more to one their desirability will be increase. Fuzzy method evaluates membership of one pixel to fuzzy sets due to fuzzy membership function. Fuzzy sets (or fuzzy classes) have no boundary and membership or non- membership of a place in a special set is gradual. This operator is in field of balance operators and it creates a suitable condition of AND and Or degree (Khan & Alnuweiri, 2004). A fuzzy set is determined by fuzzy membership degree. There are four membership functions in fuzzy grades that are S form, J form, linear and defined by user (Eastman, 1993, 112). First hypothesis- It seems that people are not satisfied by parking lots quality and quantity.

To answer hypothesis test, we combine questions number 4 to 11 for each person and resulted data were calculated for 400 people and they were analyzed by T- single sample method, hypothesis test of this test as zero hypothesis is Paveh city people are satisfied by parking lots quality and quantity. Contrast hypothesis is Paveh city people are not satisfied by parking lots quality and quantity. Hypothesis test can be rewritten based on questionnaire data (since values more than Likert range shows non- satisfaction of parking lots quality and quantity) as follows:

$$H_0 : \mu \leq 3$$

$$H_1 : \mu > 3$$

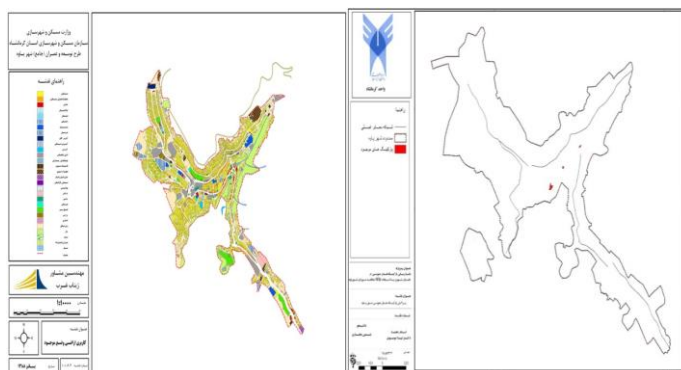
Using single T test, hypothesis 1 was tested that resulted values of analysis as follows:

Mean of questionnaire for 400 people is 4.2 and standard deviation is 0.53. T- Statistic value is 2.387 and freedom grade is 399 and since significant level is 0.01 that is lower than 0.05 so zero hypothesis is rejected and opposite hypothesis is accepted that says Paveh people are not satisfied by parking lots quality and quantity, therefore, study hypothesis is accepted.

Second hypothesis: It seems that effective factors in controlling traffic of Paveh city is not used appropriately. To reply above test, question numbers 12 to 23 of questionnaire were used and we determined by factor analysis that whether effective factors in controlling Paveh city traffic is used properly? In third column, all variable value variance estimation is determined and since all values are very far from zero, thus study hypotheses (questions 12 to 23) have effective role. We separated three main components in this study that all three account for 85.7 percent of total variance. First main component with variables of question 12 (when city old context is effective on Paveh city parking area shortage), 13 (how much shortage in parking space in Paveh city is effective in creating traffic problems), 14 (how much public parking lots are effective on solving traffic problems?), 19 (how people can help to solve traffic problems), 20 (how much non- using personal cars are effective on solving traffic problems), 22 (how much observing rules of construction is effective in solving traffic problems) and 23 (how much car appropriate park is effective in solving traffic problem) has the most relevance. Second component had the most relevance with variables of question 17 (how much making an odd and even plan for traffic is effective solving traffic problem?) and 18 (how much collecting old cars is effective solving traffic problem?). A third component has the most relevance with variable of question 20 (how much non- using personal cars are effective on solving traffic problems). It is recommended that to review effective factors in controlling Paveh city traffic, questions 15 (making building without parking) and 16 (personal cars travel in the city) and 21 (the amount of observing traffic department and attention to tableaus) should be removed because they have no relation with no main factors. Paveh city general topology was made by the use of GIS, analytic hierarchy method (AHP) and fuzzy logic.

Research jurisdiction:

Under study area for general parking lots topology: under study area for public parking lots topology is Paveh city in north west in Kermanshah province that has a border with Marivan city in the north and Ravansar city in the east and Kamyaran city and Javanrood city in the south and Iraq country in the west, this city is located in geographical situation of 34 degree and 55` to 35 degree and 18` in north width and between 46 degree and 0` and 30` to 46` in east length in a height with mean of 1540 from sea level, average annual precipitation is 830 mm and the weather is relatively cold and tend to equality and semi- humid. Its area is 258 hectare with 20885 people. It is 13 among 14 cities in Kermanshah province that shows small area of this city than other cities of this province. Gross congestion of this region is 92 people in hectare. Main passages length is 13 Km and passages level area is 57.23 hectare that is equal to 572300 m2 that cover desired level of 25% in Paveh city. Because relatively old context of passages is narrow and there are different travel absorption usages in its main passages margin, now, Paveh city has 3 urban parking units. Due to special situation of topography and city physic attraction and current traffic, doing this study in relation to public parking lots topology in city space of Paveh city will be necessitated.



Map 1. current parking lots distribution in Paveh city Map 2 current situation usage in Paveh city

Effective measures in parking topology

Table 2. effective measures in parking topology

Measures
Land gradient (land gradient floors)
Population congestion (population amount in day and night in the region, residence population congestion in the region)
Current parking lots distance from travel absorption usages
Distance from urban passages network (first order arterial streets- second order arterial streets 2- 3 rd degree streets (region streets)
Building quality (uncultivated lands and low quality buildings)
Distance from travel absorption usages (administration, business, training, cultural and healthcare centers)
Property value (region property value)

Formation of information layers in order to identify desired regions for topology and creating factor maps A data base is created to determine suitable parts for parking lots topology and its amount in Paveh city related to measures and topology indices and also, using related documents, different maps, field result and other resources for research limit and after identifying and preparing all measures and factors that are effective in topology, in this stage it is necessary to prepare factor maps of each layers. Factor maps preparation consists of two stages of process and weighting to informational layers. For this reason, data process method in GIS like transforming vector structure to raster structure, integrating several layers into one layer, preparing analysis and re classification was used and after processing layers, and measures mutual comparing in order to weight to layers in both stages based on analytic hierarchical model (AHP) and fuzzy logic was done.

Measures mutual comparison and measures binary matrix formation:

In this stage, measures are compared in couple in which due to review objective, measure superiority intensity I is assessed toward measure j. Based on this, quantity table 9 of Tomas was used to compare and judge two by two in terms of creating questionnaire and appealing experts. "Geometric mean" of experts' views are used in this section in order to obtain measure importance amount.

Table 3. weighting matrix in AHP environment

	Building quality	Distance from travel absorption usages (administrative, business, training, cultural, healthcare)	Distance from passages network	Population congestion	Land gradient	Land price	Distance of parking from travel interesting usages	Measures
0.3265	7	7	6	6	5	2	1	Distance of parking from travel interesting usages
.2181	6	6	5	4	2	1	0.5	Land prices
0.1341	5	4	4	2	1	0.5	0.2	Land gradient
0.0941	4	3	2	1	0.5	0.25	0.17	Population congestion
0.0663	3	2	1	0.5	0.25	0.20	0.17	Distance from passages network
0.0438	2	1	0.5	0.33	0.25	0.17	0.14	Distance from travel absorption usages (administrative, business, training, cultural, healthcare)
0.0227	1	0.5	0.33	0.25	0.20	0.17	0.14	Building quality
0.0484								Mean

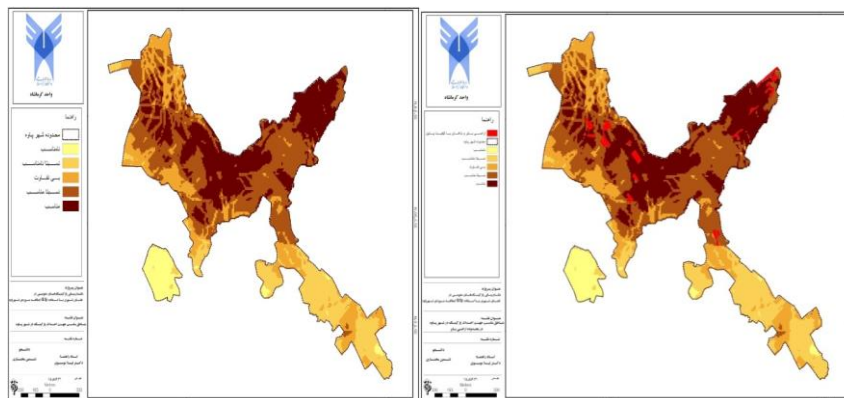
Weighting first stage of factor maps by analytic hierarchy method and second stage of factor maps in fuzzy logic method

In this stage, weighting factor maps at first was done by analytic hierarchy method and then each measure (factor) was done by fuzzy logic based on relative effect that has in topology grade determination.

In each fuzzy factor, value of each class and current location unit with fuzzy membership grades is shown by between zero and one. Some instructions in GIS software and using tools of Raster Calculator was developed and implemented in order to prepare fuzzy factor map in this study by defining linear functions and due to positive or negative effect of each parameter and regarding offered measures and criteria. Finally resulted output of each layer is a raster layer that is defined for each information layer based on classification and defined criteria, and values between zero and one are considered.

Presenting final map

Final map was obtained by integrating all effective indices for parking lots topology in Paveh city. Information of this map shows that current locations of these parking lots have common points with suitable availability ray, in contrast, there are some regions in this city that have no suitable availability with this ray and main traffic size of the city that is in the city center needs to build more parking lots.



Map 3. final map for construction of urban parking lots in Paveh city; Map 4, final map for construction of urban parking lots in Paveh city based on uncultivated lands with low quality

According to final map resulted from effective measures integration in Paveh city parking lots, we divide them into 5 classes that are totally unsuitable range with valuing about 18.2%, relatively unsuitable range about 17.1%, indifferent range about 13.2%, relatively suitable range about 27.4% and suitable range about 24.1% of all city area.

Table 4. valuing parking lots optimized places

Optimized parking lots	Valuing	Area (hectare)	Percent
Totally unsuitable	1	41.2958	18.2
Relatively suitable	3	38.7999	17.1
Indifferent	5	29.9508	13.2
Relatively suitable	7	62.1706	27.4
Totally suitable	9	54.6829	24.1

This hypothesis tries to measure how Paveh city parking lots per capita is distributed in terms of optimized standards; that according to results from current per capita amount and suitable suggested per capita from Paveh city, that is shown in table 5, we can say:

Table 5. usage per capita amount of Paveh city parking lots

Region area	Total area of desirable parking	Current population	Current per capita	Standard per capita	Required land in m2	Shortage amount
15872	20885	1 m2	0.24	20885	20885	258 hectare

Current per capita (urban parking lots) is 0.24 m2 that according to current area region and its population in 2010 whose population were 20885 people and standard per capita was at least 1 m2, it is clear that at the moment 15872 m2 parking lots is needed in this region in order to reach this usage to the 1 m2. Therefore, as it is shown in above table, it was determined by reviewing that Paveh city parking per capita is 0.24 m2 that a severe shortage is felt in comparison with calculated standard per capita for Paveh city in Country Urbanization and Housing Ministry point of view whose minimize and maximize are 1 and 1.5 m2, respectively, thus it is concluded that Paveh city parking lots are not distributed properly in terms of optimized standards due to an appropriate per capita

RESULTS AND DISCUSSION

In this study, total objective is evaluating and analyzing public parking lots optimized topology in Paveh city and their correct topology in order to offer more appropriate function and services and reducing traffic congestion and solving developmental problems of this city. Data collection was done through referring to organizations, people and questionnaire. After collecting data, questionnaires were extracted and they were transferred to the computer and then they were analyzed with the use of statistical software package for social sciences. Data analysis was described

in terms of frequency distribution tables using descriptive statistics indices and statistical samples cross section tables. Also, sample single T test and factor analysis were used to analyze relation between dependent and independent variables. Based on study empirical findings it was determined that different indices together should be reviewed in order to reach urban sustainable development and using only one index would not respond to other needs; thus in this study after calculating current per capita of Paveh city parking lots and its comparison with study acceptable standard per capita, under study indices that are obtained by urban sustainable development approach were reviewed by fuzzy technique and it was determined that analysis techniques Fuzzy_GIS can offer an appropriate topology due to special complicate of different factors for urban parking lots; because this technique had a high capability in topology and it offers appropriate guidelines in topology for parking lots by reviewing different factors and analyzing them. Considering current situation of Paveh city parking lots, at the moment total amount of current parking lots is 4285 m² and this usage is considered warehouse and transportation usage, total current parking lots area and warehouse and transportation usage is 5013.6 m². Suggested per capita for each people are 1 m², current shortage for this usage in current situation is 0.76 m² for each person, totally 15872.6 m² is required space for this usage. Parking usage per capita is 0.24 m² per citizen in Paveh city in current situation. Paveh city population is 20885 people and suggested per capita is 1 m² for each person in comprehensive plan that is due to suggested per capita and population, we should have totally 20885 m² for parking usage (warehouse and transportation usage). Difference between current situation and suggested per capita of 1 m² for each person is - 0.76 m² and by estimating 15872.9 m² required space to build parking and by topology of these parking lots, analytic hierarchical method (AHP) and fuzzy logic in GIS environment were used to determine final map and ranging regions in 5 classes of suitable, relatively suitable, indifference, relatively unsuitable and unsuitable; it was determined that 24.1 percent of Paveh city space is suitable that 15 new places were suggested to build public parking lots.

Table 6. suggested places for building Paveh city public parking lots

1-	Shohadaye 26 Mordad Str., after former prison beside Shahsavarie store until taxi Saba
2-	Holy Sarab Str., (education) at the end of Tekie street, after Molem Shomalie high school, Education
3-	Imam Mohammad Shafeie Str., After the road, against Seyed Mahmood Isfahainie tomb
4-	In the beginning of Kamarbandi Str., under the road, against Eghbaliha house
5-	At the end of Imam Mohammad Shafeie Str., against guarding of water and sewage pump
6-	Imam Mohammad Shafeie Str., against guarding of water and sewage pump
7-	At the end of Imam Mohammad Shafeie Str., and in the beginning of Cetral Str., beside old Behdarie Building
8-	In the beginning of Central Str, in the north of old Behdarie Building
9-	Tomb Str., toward Imam Ali mosque, beside Martyr Hatamie Besiege Center
10-	Tomb Str., beside Imam Ali mosque
11-	Tomb Str., beside gendarmerie... below part toward Hotel Eram
12-	Imam Mohammad Ghazalie Str., beside transport and route administration
13-	Imam Mohammad Ghazalie Str., against disciplinary forces headquarters, beside Gas station
14-	Salahodin Ayoobie Str., between Custom and Seifie driving training
15-	Imam Mohammad Ghazalie Str., beside Behzistie office

Suggestions

- Increasing quality and quantity of parking lots, because based on study findings, improving parking lots situation lead to keep social human abilities and privileges.
- Using information technology especially GIS to analyze broad range of data in order to obtain and quick achievement to information and forming a concentrated data base by spending minimum cost and time and also giving trustful predictions to urban officials.
- Making multi- floors parking lots, because valuable and rare lands of city will be used better.
- It is suggested that usages with high attractive travel change into low attractive travel places rather than adding to these usages.
- Doing supportive and encouragement plans for users of public parking lots and encouraging in the field of using public transport in line with reducing traffic problems
- Preventing residence buildings construction without parking by municipality officials and making parking in residential units
- Upgrading people role as main users of urban parking lots via giving necessary trainings trough teaching culture in terms of using parking and correcting parking behavior

Cheap price spaces and uncultivated lands should be preferences for public parking lots topology, current area should be considered per person of Paveh city population according to global standards and parking lots should be increased in urban level with population increase.

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