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PUBLIC PARKING SPACES IN URBAN SPACE AND TRAFFIC CONTROL OF PAVEH CITY

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ABSTRACT

This research surveys the public parking spaces in urban space and traffic control of Paveh city by the use of analytic hierarchy process (AHP) of fuzzy logic in GIS environment. In terms of the research aim the research method is applied and in terms of research framework it is analytical-descriptive. Data are collected through field and library methods by the use of 400-individual questionnaires and interviewing experts; also techniques such as weighting, allocating points and data combination, AHP of fuzzy logic and indicators overlap are considered as highlights of this research. The research results have resulted in categorizing the scope of research studies in two five classes of appropriate, partly appropriate, indifferent, partly inappropriate and inappropriate. The achieved results showed that the appropriate places for constructing parking spaces in Paveh city does not include the current places indicating the lack of distribution fitness of this use with the calculated standard per capita; and there is a lack of enough parking space with an area of 15872 square meters; and the current space not only does not handle the urban congestion, but also not constructed in an appropriate place. Around 24.1% of total urban space which is 54.6829 hectares of appropriate lands (based on the undeveloped lands and low-quality constructions), in case of obtaining the private land owners' consent and coordination with the municipality and cooperation of authorities, are recognized for constructing parking spaces and the final map shows the location of these lands for constructing public parking spaces in different parts of the city.

Keywords: *Public Parking, Geographical Information System (GIS), Analytic Hierarchy Process (AHP), Fuzzy Logic, Paveh City*

INTRODUCTION

With rapid growth of urbanization during the recent decades and increased number of motorcycles, traffic in urban streets has become one of the main issues of the cities. On the other hand traffic on roads affects all activities of the citizens and one of the concerns of the urban managers is solving the traffic issue in cities. In order to have smooth traffic and solving this problem many measures have been taken such as constructing urban transport infrastructure like connection roads, underpass and overpass, squares and also expanding the public transportation such as city buses by the urban managers. In this regard, constructing several public parking spaces near the urban streets which results in preventing from long hours of parking the cars along the streets is one of the effective factors resulting in reducing traffic. Location and construction of urban land uses such as public parking spaces are some of the essential needs of many cities that are conducted for citizens' welfare and solving the problems of cities. If these actions are performed without paying attention to the effects and interactions between the uses they may result in more problems than solving them. Thus it is necessary to study and to take serious all the factors related to this problem (Ghazi, 2004). One of the most important parameters affecting the construction of parking spaces is the place of their construction; inappropriate place for constructing parking lots and their non-normative dispersion result in their inefficiency and also increased urban traffic and as a result it causes increased urban traffic, increased car accidents, increased time and distance of trips within the cities, increased fuel consumption, increased air pollution and noise pollution (Ghazi, 2004).

Paveh city is considered as one of the elevated cities of the Kermanshah province that has significant lack of parking lots. Regarding the topography of Paveh, the landscape of this city is mountainous including

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mountains and hills that the highest area of its lands include 15 to 20% and it has severe lack of lands. Expensive limited lands, traditional context and inapplicability of the current projects regarding the streets because of their expenses, existence of trip attraction uses such as business and service centers like clinics, drugstores, and also lack of parking lots, inappropriate location of this use and problems related to stoppage of vehicles, increased traffic of private cars, lack of appropriate service provision, and limited access to the city entry all result in heavy traffic. Heavy traffic is observable in this city due to lack of parking lots in the main streets such as 26 Mordad, Islamic Revolution St., and Imam Khomeini St., using traditional methods in construction, lack of logical and rational methods of using rare and expensive lands. In order to have smooth traffic and in order to reduce the traffic problems of Paveh city, and also in order to organize the urban space and satisfy the citizens, public parking lots must be constructed and distributed in appropriate places; thus this research tries to study the current conditions and survey the uses of Paveh city such as parking space uses by determining the important and effective factors of optimal parking location and by the use of GIS (AHP and fuzzy logic) in order to solve urban transport problems such as optimal public parking spaces and also finding strategies for reducing the heavy urban traffic. Nowadays one of the most important and most serious problems engaging many of our cities is the problem of lack of private and public parking lots in different places and especially crowded places. Providing the required space in dense areas such as shopping centers and business centers and also residential areas along with lack of space in streets and lack of parking lots has always been one of the urban problems. Searching for empty spots, drivers stopping to park their vehicle especially in high-density streets result in wasting considerable resources and time along with resulting in increased air pollution in that area (Shahabi *et al.*, 2011).

Research Importance & Necessity

Research Importance: A part of daily trips within the city is conducted by the use of public transport system and another part is conducted by the use of private vehicles. Increased use of private vehicles on one hand causes heavy traffic in streets and on the other hand causes reduced efficiency of public transport system. Drivers of private vehicles always look for empty spots to park their vehicles and this result in more traffic. Urban experts and managers think about public places to reduce traffic caused by inappropriate parking of vehicles around the streets.

Thus public parking lots are a part of urban transportation system. The role of public parking lots could be surveyed in two manners:

- 1- Construction of more public parking lots around the city and especially in high-density areas results in smooth traffic.
- 2- Construction of public parking lots serves and encourages the private vehicles and thus for access to better services these parking lots must be constructed around the high-density areas (Moshgini, 1009).

Research Necessity: Regarding the increased population of Paveh city and its topography in terms of structure, slope and increase number of private cars, and also inattention to the problem of parking along with development of streets in the urban transportation system which results in heavy traffic and other problems, cars parked around the streets and most importantly the citizens' inattention to observance of civil rights and traffic rules all have resulted in chaos in this city. Thus predicting appropriate parking space for cars, especially in high-density areas and center parts of the city results in less fuel consumption, reduced depreciation of vehicles and undesirable mental effects, reduced number of vehicles looking for parking spots and also reduced latency in this network. Constructing public parking lots is an inevitable necessity for controlling heavy traffic around the bazaar area and also controlling the stoppage of cars around the streets. Lack of parking lots in the city of Paveh and while passing this city creates this question that notwithstanding all vehicles parked around the city what is going to happen to the vehicles manufactured in the future and where are they going to be parked?

Research Aims

General Aim

Providing appropriate strategies for solving the problems; and increasing the public satisfaction in terms of quality and quantity of parking lots.

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Research Questions

3- Are the effective factors used appropriately for controlling the traffic in Paveh city?

Research Hypotheses

2- It seems that effective factors are not appropriately used for controlling the traffic in Paveh city.

Research Background

Along with this research, several studies have been conducted in Iran and around the world and some of them are as follow:

Robert (1987) has conducted studies regarding the use of GIS in location of urban service centers and especially parking spaces and has also conducted studies regarding the needs of some of the cities of America to new parking spaces by the use of GIS. During a study related to the car accidents in 10 cities of the USA, Salter (2001) has shown that in 53% of all car accidents within the cities, parking cars near the streets have been involved. Cysido (2010) surveyed the effect of data management of access to parking spaces on reduced time of looking for parking spots and reducing the environmental pollution; and he achieved this result that the distance for reaching a parking space, time spent for looking for a parking spot and the distance of side walk between the parking space and the destination have significant effect on reaching this aim.

5-In an article about the urban sustainable development, Ahmadi and Habib (2006) emphasized on walking in Asia regarding the increasing population of cities, increased number of vehicles and also the increasing share of streets in the urban structure which result in several problems for today's cities that must be solved through new methods and providing new strategies. Paying attention to human beings is the most important factor in formation and life of cities and paying attention to some of the most important needs of human beings such as mobility, health, and improving the social life in cities are the important aims of this article.

7-Javanshir & Ghadimi (2009) used AHP methods for locating optimal public parking spaces by the use of fuzzy GIS in the western central area of Mashhad and their aim was providing the optimal model for locating parking spaces and they concluded that the used models were appropriate for locating parking spaces.

8- HosseiniLaghab (2011) studied locating public parking spaces in Ganaveh city and after estimating the construction and number of parking spaces by the use of parking production method regarding the optimal situation of constructing public parking spaces by the use of AHP in GIS software environment and appropriate places were highlighted by the use of fuzzy OWA method.

MATERIALS AND METHODS

Research Method

Based on aim the current research is an applied research and from the point of framework it is an analytical-descriptive survey. The research tools are questionnaire and GIS software. This research is a field study. Data are collected through field study and studying the area and the current situation of parking spaces in Paveh city and estimating the required parking space. Then the hypotheses are proved by the use of questionnaire and SPSS software. Then by determining parameters and parameters affecting the parking location, a databank is provided from each of the layers and the spatial analyses are conducted; after that, by the use of AHP the parameters are weighted and by the use of fuzzy logic model and linear membership function the layers are graded and at the end by the use of graded layers overlapping method a single map of optimal public parking spaces is achieved.

Research Domain

Thematic Domain

In terms of study field, the research thematic domain is in the field of Municipal and urban development and removing problems (picking up and removing development barriers).

Spatial Domain

The place of conducting the research is Paveh city located in northwest of Kermanshah Province with 112km distance from the center of province and city of Kermanshah with an area of 2580000 square meters and the population of 20885.

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Time Domain

In terms of time this research surveys a period from July/2014 to January/2015.

Statistical Population, Sampling Method & Sample Size

The statistical population includes all elements and individuals in a specific geographical scale (global or regional) having one or multiple mutual characteristics (Hafeznia, 2008).

Regarding the research subject the statistical population includes the citizens of Paveh city; and the random sampling is used for simplifying the statistical sample size.

The research statistical sample size is achieved by the use of Cochran formula and Morgan table. Based on this, regarding the statistical population of Paveh city that includes 20885 individuals, the random statistical sample size includes 377 individuals.

Regarding the formula and the statistical population, the statistical sample size is equal to 377 individuals and for completing the task, the statistical sample size includes 400 individuals (n= 400 individuals).

Cochran formula for estimating the sample size:

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

Data Collection Tools

Determining data collection tools is conducted regarding the chosen method. In other words, each method has its own tools by the use of which the researcher can collect and classify data (Hafeznia, 2008).

1- Documentary Method: At the first stage the researcher's field observations (aerial photos and personal observation), theoretical data of scientific centers, libraries, books and articles, internet and numerical data from statistical centers and resources are collected from the existing maps, and (comprehensive) development plan of Paveh city.

2- Interview method: interview method based on interviewing with authorities and managers of urban planning and citizens.

3- Questionnaire method: Questionnaire is used for developing and completing the information estimation in descriptive researches which includes a vast geographical area/the population and sample are huge. Firstly by detecting the information resources the questionnaire is developed and the questions explain the hypothesis.

According to the advantages and features of the questionnaire including being affordable, easiness, and accuracy, having enough time for filling it out, providing similar questions for all individuals and also simplicity and accuracy of extraction, and analysis of results, this tool is used.

The collected data are analyzed by the use of SPSS software.

1) Data Analysis Method

Data analysis method in the current research includes two parts: 1- data collection is conducted by the use of quantitative method, and questionnaires and then data analysis and inferential statistics are conducted by the use of SPSS software. 2- By the use of GIS, AHP and fuzzy logic, the optimal public parking spaces are located in Paveh city.

Research Variables

1-12-1- Independent Variable

Public parking spaces, urban spaces

Dependent Variables

People's satisfaction, factors affecting the traffic (urban old context, lack of parking space, increased public parking spaces, preventing from constructing houses without parking lots, even-odd traffic plan, collecting old vehicles, help removing traffic problems, lack of using private cars, observing the traffic rules, observing construction rules and appropriate parking method).

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Methodology and Introduction to Studied Domain

Research Type and Method

From the point of aim the current research is an applied research and from the point of framework it is descriptive-analytical. Research evaluation method is questionnaire and GIS software. The current research is a field study and the information is collected through field method, library, and internet and interviewing with experts. By the use of data collection, surveying the research area and the current status of the parking spaces in Paveh, the required parking space is estimated and by the use of questionnaire and SPSS software the hypotheses are proved.

Firstly a database is developed for each layer and spatial analyses are conducted, then by the use of AHP the parameters are weighted and by the use of fuzzy logic model (the desirability of each class in each sub-scale based on the fuzzy model) and the linear membership function the layers are graded and at the end by the use of graded layers overlapping, a single map of the desirable public parking spaces is developed.

The procedure is shown in the following table:

Table 1: Stages of locating the parking spaces by the use of AHP and fuzzy logic in GIS environment

Stages of locating the parking spaces by the use of AHP and fuzzy logic in GIS environment	
1-	First stage: choosing the surveyed area
2-	Second stage: determining criteria, and sub-criteria
3-	Third stage: Developing and preparing the information layers in GIS environment, prioritizing and weighting by the use of AHP
4-	Fourth stage: Grading and combining layers by the use of fuzzy logic model (surveying desirability of each class in sub-criteria based on fuzzy model)
5-	Fifth stage: Combining information layers in GIS
6-	Sixth stage: Providing the final map

Source: Author

AHP Procedure

In AHP method, binary comparison method is used. In order to use this method firstly each of the criteria are compared and the relative importance of each pair of ratio is given a grade between 1 to 9 and imported in a matrix and it is evaluated pairwise and weight of each of them compared to the other one is determined; then at the second stage, by the use of normalization all measures are weighted.

At the third stage, by the use of weight of measures and the grade of alternatives, the combinatory weight of each of sited is achieved by the use of multiplying the coefficient of weight of measures and the alternatives' points and sites are graded based on the achieved weight; at the final stage, the compatibility is determined which is used by the analyzer (Hosseini, 2000).

Table 2: AHP Procedure

Score (severity of priority)	Definition
1	Equally referred
3	Moderately referred
5	Strongly referred
7	Referred very strongly
9	Extremely referred
2, 4, 6, 8	Intermediately referred (when there is a middle mode)

Source: an example of pairwise comparison matrix (Zebardast, 2001)

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Fuzzy Logic Method

In fuzzy logic each class has a membership indicating the level of its desirability and each layer is graded in a scale of zero to one; which means 1 is the highest desirability and zero is lack of desirability. And there is range of numbers between these two numbers and the more close to 1 the more desirability. Fuzzy method evaluates the probability of membership of a pixel in a fuzzy set based on the fuzzy membership function. Fuzzy sets (and/or fuzzy classes) lack a specific border and the membership or lack of membership of a place in a specific set is gradual. This operator is in the area of balanced operators and it provides a suitable condition of OR and AND (Khan & Alnuweiri, 2004). A fuzzy set is determined by the use of degree of fuzzy membership. There are four membership functions in fuzzy degrees including S form, J form, Linear and defined by the use (Eastman, 1993).

Statistical Population, Sampling Method & Sample Size

Paveh city with a history of more than 3 thousand years is located in northwest of Kermanshah Province with 112 kilometers distance from the center of province and Kermanshah city; and due to its stair structure, it is known as the thousands of Masuleh. Paveh is chosen as the center of Paveh and Hawraman County from 1959 and due to the location of its resources and 850 square kilometers area (803 square meters in the comprehensive plan), the comprehensive political plan of this county and its role in political currents; it has a special situation in the west part of the country.

The area of Paveh County is 16875646 square meters and the area of Paveh city is 2580000 square meters and from north it neighbors Marivan, from east it neighbors Ravansar and Kamyaran, from south it neighbors Ravansar and Javanrud and from west it neighbors Iraq.

Paveh city is in the area of 34 degrees 55 minutes to 35 degrees 18 minute north latitude; between 46 degrees and 0 minutes and 30 seconds to 46 minutes east longitude and averagely 1540 meters above the sea level.

The average annual rainfall in this area is 830 millimeters and it has relatively cold, semi-wet weather. It includes three districts, 4 cities and 5 villages. Based on census conducted in 2010, the population of Paveh city is 20885 individuals (Comprehensive development plan, 2010: 43).

Sample Size

Regarding the research subject, the statistical population includes the citizens of Paveh city. The random sampling method is used in this research and for simplifying the sample size, the cluster sampling is used. The research statistical sample size is achieved by the use of Cochran formula and for more accuracy Morgan table is also used. Based on this, regarding the population of Paveh city (20885 individuals), the sample size of the statistical random population is 400 individuals.

According to the formula and the statistical population, the statistical sample size equals 377 individuals and for completing the task, the statistical sample size includes 400 individuals (n= 400)

Cochran Formula

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

Data Collection Method

Determining data collection tools is conducted according to the chosen method; in other words, each method includes its own specific tools by the use of which the researcher could collect and classify the data (Hafeznia, 2008).

1- Documentary Method: At the first stage the researcher's field observations (aerial photos and personal observation), theoretical data of scientific centers, libraries, books and articles, internet and numerical data from statistical centers and resources are collected from the existing maps, and (comprehensive) development plan of Paveh city.

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Validity and Reliability of Data Collection Tools

Validity

A good test must include a number of desirable features such as objectivity, ease of implementation, practicality, ease of interpretation, validity and reliability. The most important features are validity and reliability; validity means that the scale and the tools or questions embedded in the tools must accurately measure the variables and the studied subject; in other words, they must well show the reality. For more accuracy the questionnaire was handed out to a group of experts in this profession and the experts also approved the validity of the questionnaire; which shows that the questionnaire has acceptable (face) validity.

Reliability

Reliability is a tool interpreted as a tool for credibility, accuracy and trust; in other words reliability is a tool for measuring variable and attribute created in similar conditions used in other place or time showing similar results. Reliable tool is a tool having repeatability and measuring similar results. The relationship between validity and reliability is that a test must be reliable in order to be valid. If a test shows different results on a sample for several times, this test is not reliable and in fact it cannot measure anything appropriately; and if a test does not appropriately measure something, the information are not useful at all (Hafeznia, 2008).

Cronbach alpha is used for evaluating the reliability of the questionnaire. Thus the Cronbach alpha is calculated for all items; the amount of calculated alpha for all surveyed dimensions is more than threshold of 0.65.; thus the reliability of the questionnaire is approved.

Data Analysis Method

Table 3: Communalities

	Initial	Extraction
s12	1.000	.599
s13	1.000	.637
s14	1.000	.635
s15	1.000	.559
s16	1.000	.463
s17	1.000	.606
s18	1.000	.673
s19	1.000	.575
s20	1.000	.618
s21	1.000	.501
s22	1.000	.742
s23	1.000	.437

Extraction Method: Principal Component Analysis.

Data analysis method in the current research includes two parts: 1- data collection is conducted by the use of quantitative method, and questionnaires and then data analysis and inferential statistics are conducted

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by the use of SPSS software. 2- By the use of GIS, AHP and fuzzy logic, the optimal public parking spaces are located in Paveh city.

Table 4: Total Variance Explained

عوامل	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.901	32.512	32.512	3.901	32.512	32.512	2.536	21.137	21.137
2	2.004	16.702	49.213	2.004	16.702	49.213	2.291	19.090	40.227
3	1.140	9.503	58.717	1.140	9.503	58.717	2.219	18.490	58.717
4	.845	7.041	65.758						
5	.823	6.859	72.617						
6	.724	6.031	78.648						
7	.596	4.969	83.617						
8	.551	4.589	88.205						
9	.435	3.622	91.827						
10	.391	3.259	95.087						
11	.339	2.827	97.914						
12	.250	2.086	100.000						

Extraction Method: Principal Component Analysis.

In the above mentioned table, three main research components are separated and all of them explain 85.7% of total variance.

Table 5: Component Matrix^a

	Component		
	1	2	3
s12	.706	-.063	-.310
s13	.662	.091	-.436
s14	.605	.284	-.435
s15	.529	-.420	-.320
s16	.518	.441	.013
s17	.444	.626	.132
s18	.353	.728	.133
s19	.601	-.230	.401
s20	.579	.137	.514
s21	.531	-.468	.027
s22	.624	-.560	.200
s23	.600	-.119	.249

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

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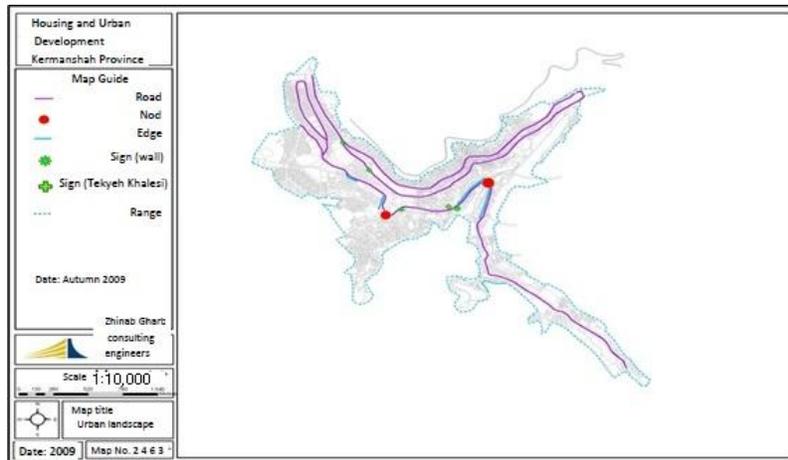
Hypothesis: It seems that factors effective on controlling traffic in Paveh city are not appropriately used. Questions 12 to 23 are used for answering the above mentioned test; by the use of factor analysis it is determined whether the factors effective on controlling traffic in Paveh city are appropriately used or not. In the above mentioned table, the third column indicates the variance estimation of each variable for components; and since all amounts have distance from zero thus the research variables (questions 12 to 23) have effective role.

According to the above mentioned table, the first main component has the highest relationship with variable questions 12, 13, 14, 19, 20, 22 and 23.

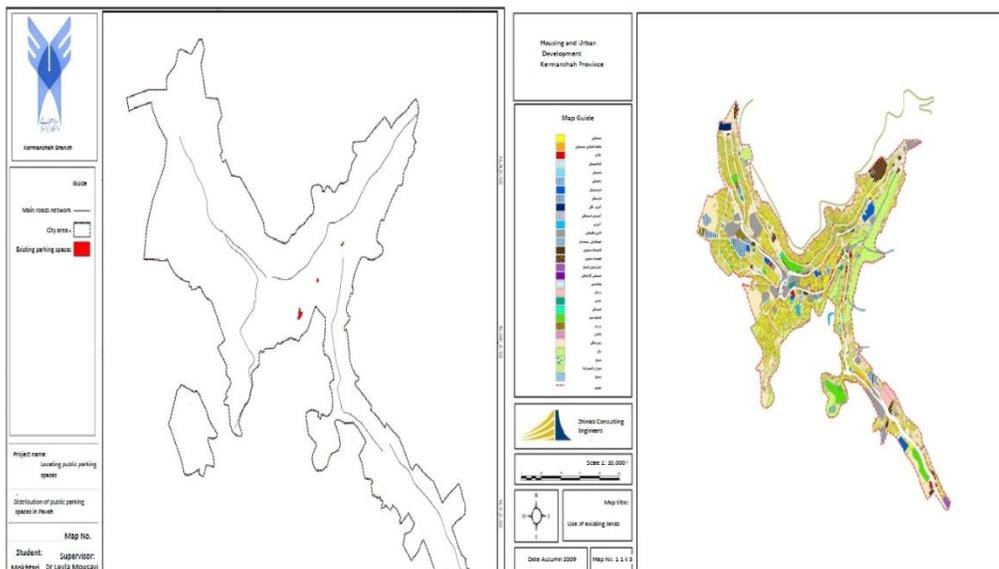
The second component has the highest relationship with variable questions 17 and 18.

The third component has the highest relationship with variable question 20.

Thus it is recommended that for surveying the factors effective on controlling traffic in Paveh city, questions 15 (constructing houses without parking spaces), 16 (movement of private cars inside the city) and 21 (paying attention to traffic rules and signs) must be omitted because they have no relationship with any of the main factors.



Map 1: Urban landscape of Paveh city



Map 2: Status of current parking space distribution in Paveh city. Map 3: Use of the existing situation

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DISCUSSION & CONCLUSION

Hypothesis: It seems that factors effective on controlling traffic in Paveh city are not used appropriately. For answering the above mentioned test, questions 12 to 23 of the questionnaire are used; and by the use of factor analysis it is determined that whether the factors effective on controlling traffic in Paveh city are used appropriately or not.

In the third column the variance estimation of each variable was determined; and since all amounts have distance from zero thus the research variables (questions 12 to 23) have effective role.

Three main research components are separated and all of them explain 85.7% of total variance.

The first main component has the highest relationship with variable questions 12 (to what extent the old context of city is effective on lack of parking space in city of Paveh), 13 (to what extent lack of parking spaces in Paveh city is effective on creating traffic problems), 14 (to what extent the increased amount of public parking spaces is effective on solving traffic problems), 19 (to what extent the help of people is effective on solving traffic problems), 20 (to what extent lack of using private cars is effective on solving traffic problems), 22 (to what extent observing the traffic rules is effective on solving traffic problems) and 23 (to what extent the appropriate method of parking cars is effective on solving traffic problems).

The second component has the highest relationship with variable questions 17 (to what extent the even-odd traffic plan is effective on solving traffic problems) and 18 (to what extent collecting old cars is effective on solving traffic problems).

The third component has the highest relationship with variable question 20 (to what extent lack of using private cars is effective on solving traffic problems).

Thus it is recommended that for surveying the factors effective on controlling traffic in Paveh city, questions 15 (constructing houses without parking spaces), 16 (movement of private cars inside the city) and 21 (paying attention to traffic rules and signs) must be omitted because they have no relationship with any of the main factors.

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