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Access Enhancement by Making Changes in the Route Network to Facilitate Rescue Operations in Urban Disasters

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ABSTRACT: Having access to locations struck by natural environmental disasters is one of the chief necessities in urban disaster management. This paper aims to study different physical and semi-physical patterns for increasing access to different districts in a city through applying changes to the present network of routes. To attain this goal, District 6 of Tehran Municipality was selected for the case study. The technique used in this research is based on multi-criteria decision- making methods. Thus, the patterns and indices were extracted by means of AHP method, and then the indices were assigned weights. These patterns were, then, analyzed and ranked through TOPSIS, FUZZY and SAW techniques respectively. Next, the results were combined by means of Borda method. The results indicated that A_4 pattern which obtained 7 maximum scores was the most efficient pattern in increasing access through changes in the network of routes. Next to it is A_3 pattern which ranked second. It is, therefore, suggested that in order to increase access for rescue operation in urban disasters, parallel routes in directions of the first and second priority, east to west and north to south, must be constructed so that arterial roads in the district offer better services in normal and emergency conditions.

Key words: Disasters, Access, Pattern, Fuzzy, Topsis, Saw, Borda

INTRODUCTION

Access to the areas struck by the disaster is of highest priority in the aid rescue operation after urban disasters (Chang *et al.*, 2002). In this respect, it is necessary that inner-city route networks maintain their performance condition after the disaster so that they can at least provide the same service in emergency conditions as that they did before the crisis. But recent earthquake disasters have repeatedly demonstrated the seismic vulnerability of urban transportation systems (Basöz and Kiremidjian, 1995; Chang *et al.,* 2000). Spectacular highway bridge failures occurred in the 1989 Loma Prieta event that struck the San Francisco Bay Area, the 1994 Northridge earthquake in the Los Angeles metropolitan area, and the 1995 Hyogoken-Nanbu disaster in the Kobe region of Japan (Chang and Nojima, 2001). The loss to the regional economies estimates that of the $6.5 billion in business interruption losses caused by the Northridge earthquake, some $1.5 billion could be ascribed to transportation system damage (Gordon, *et al.*, 1998) . After Loma Prieta earthquake the systems performance was studied include on network reliability analysis that modeled traffic flow adjustments (Wakabayashi and Kameda, 1992). Other researches in their methodology for bridge retrofit prioritization, utilized a bridge importance measure based on network connectivity analysis (Basöz and Kiremidjian , 1995). Models of bridge damage, network traffic flows, and the costs associated with travel time delays were done after disasters (Werner *et al.,* 1997).

The above studies focus on the performance of the transportation network in the emergency conditions after the disaster and seek criteria to assess the performance of the transportation network after the disaster. But the performance

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of the network of routes after the occurrence of urban disasters is not just a function of the features of the road. Human factors and the specifications of the disaster also affect the performance of the network.

Urban vulnerability to natural hazards such as earthquakes is a function of human behavior. It describes the degree to which socioeconomic systems and physical assets in urban areas are either susceptible or resilient to the impact of natural hazards (Rashed and Weeks, 2003). Several models of urban vulnerability have been proposed to address the various ways by which society becomes subject to hazard impacts (Burton *et al.,* 1978; Mitchell et al. 1989; Cutter, 1996; Menoni and Pergalani, 1996; Menoni, 2001).The concept of human/nature interaction is firmly entrenched at the heart of these models representing natural hazards as dynamic phenomena that involve people not only as victims but also as contributors and modifiers (Kates, 1996).

Interaction between man and the environment leads to the complication of the analysis of man's performance in emergency conditions. Therefore, to eliminate this complexity, the emphasis is often placed on the environmental factor, which, due to its physical nature, facilitates solving this problem. This study seeks optimal mechanisms for increasing access after urban disasters. To this end, we limited the scope of the study to the urban transportation system and analyzed patterns of change to be made in this network in order to maximize efficiency in aid operation after the disaster. It must be noted that effective aid and rescue operation after disasters is significantly dependent upon the performance of the transportation system. Thus we selected District 6 of Tehran Municipality as a case to study patterns of increasing access in extraordinary conditions. The techniques used for comparing the methods suggested for changes in the networks of the routes in the district are based on multi-criteria decision making.

MATERIALS & METHODS

Tehran is the Capital of Iran is located on slopes of Alborz Mountains and the foot of Damavand (Karbassi *et al.,* 2008). The average length of travels in Tehran greater area has changed from 8.9 Km in 1986 to 33 Km in 2000 and the average length of travels in Tehran city had an increase 2.4 to 8.1 Km within the same time period (Pourahmad *et al.,* 2007). Tehran has 22 municipality districts. In this research district 6 of Tehran is studied.

District 6 of Tehran Municipality has specific characteristics such as location centrality in Tehran megalopolis.The location of its connective and traffic knots between northern, southern, eastern and western areas has led to the establishment of numerous administrative-business activities and occupancies in metropolitan, regional, national or even ultra-national scale and finally the functional centrality of this district in the city of Tehran. These have made the district the most important section in the central nucleus of the city of Tehran in terms of the type, scale, and performance range of occupancies and spatial diversity.This district with an area of 2138.45 hectares covers about 3.3 percent of the city. In terms of geographical location, district 6 is located in the central portion of the city of Tehran. It is limited to the north by District 3, to the east by District 7, to the south by Districts 10, 11 and 12 and to the west by District 2.

The hierarchical presence in the function scale of the occupancies, from the block scale to district, city and ultra-urban scales, and the location of the district in the geometrical center of Tehran in terms of access has had a direct effect on the required occupancies of the urban category. About %35 of the district is allocated to residential occupancy, more than %30 to other occupancies (administrative, commercial, cultural, educational etc.) and about %30 to transportation (access network, transportation and warehousing).The district is considered as a laboratory for urban planners since there are several ministries, hospitals with national and ultra-national performance and churches. Most important of all, Tehran University, which is the site of Friday Prayer, and numerous bookshops are located in this district.Since it is located on the northern edge of the central portion of Tehran, District 6 not only suffers from transportation problems and its relevant trip absorption, but also is pressurized by the problems of the passing traffic. The district somehow has a checkered (systematic) network of routes and a hierarchy of access. On the other hand, the location of the district in the linking center of Tehran has brought about certain traffic features. Considering the pattern of daily trips in

Tehran, district 6 not only attracts the highest portion of daily trips, it is also located on the way of the passing traffic from districts 1, 2, 3, 4, 5, 7 and 22 (Statistical reports of District 6).

An analysis of the location and distribution of the occupancy of urban lands in the district shows that the occupancy portion of the route network in the district is %27 ranking second next to residential occupancy. From the entire network of routes, the portion of first-class arterial roads is %9, second class arterial roads %37 and minor second-class arterial roads %53. The network of urban routes is made up of a regular hierarchy ranging from impasses and alleys to urban highways. Such highways as Resalat, Hemmat, Chamran, Modarres and Kurdistan path through or from the periphery of this district and play an important role in speeding up the traffic. This area is usually the link between the north and south of Tehran and to some extent between its east and west. Due to the ultra-district role of most of the occupancies, lack of an effective network of highways inside the district, dependence upon major and minor arterial roads in most day hours especially rush hours, district 6, is faced with a heavy rush of vehicles and slowness of movement. As we move toward the southern and eastern parts of the district, we see a denser traffic, more traffic jams and delays in intersections. The most serious problem is observed in the intersections of Enghelab, Karim Khan, Vali-e Asr, Kargar, Towhid, Motahhari streets, and Keshavarz Boulevard. In addition to the ultra-district role, there are other important reasons for the situation, including lack of proper phasing and movements in intersections, lack of control and organization for off-street parking, shortage of parking spaces, and excessive use of private single-passenger cars (Statistical reports of District 6). Vast sections of the southern part of the district are located in the traffic plan limits; however , they are still faced with the problem of dense traffic and slowness of movement. The plan has hardly changed the traffic conditions of the district.(Fig.1).

The technique used in this study was based on Multi-criteria decision- making methods. To do the analysis, the following steps were taken:

Step one: In the first stage, the relevant alternatives for increasing the emergency access level were studied and finally a nine-fold pattern was extracted. After extracting the patterns, the indices for the evaluation of the alternatives were defined. Overall, 5 positive, negative and divergent alternatives were detected.

Step two: Using the Analytic Hierarchy Process (AHP), the hierarchical structure was made. The criteria were pair-compared in different levels of analysis by means of Expert Choice Software, and the local and global weights of the indices were detected.

Step three: After extracting the weight of the indices, three techniques, namely TOPSIS, FUZZY and SAW, were used to compare and prioritize the criteria .To do this, first ranked the nine patterns by TOPSIS method .Then, in two stages, FUZZY and SAW methods were also used to compare the results of the analyses of these methods. In order to come up with a precise conclusion on which to make judgment, we combined the three methods.

Stage 4: By means of collective agreement in decision making through ranking under Borda Rule, the results of ranking with the three techniques of the third step were combined and the final ranking was done based on this method to detect the proper patterns.

RESULTS & DISCUSSION

With regard to above techniques and investigations the following findings are presented. In Table 1 the Patterns proposed for increasing access in emergencies was presented.In Table 2. the evaluated indices have been defined. These indices can be classified in two groups: feasibility indices and effect on access indices.Having defined the nine patterns for increasing access in emergencies through changes in the network of present routes, the decision-making matrix has extracted .Table 3 displays this matrix .The AHP approach, Developed by Satty (1980), is one of the more extensively used MCDM methods.

The AHP has been applied to a wide variety of decisions and human judgment process (Lee *et al.*, 2001). Applying the AHP procedure involves three basic steps (Harker and Vargas, 1987):

- The hierarchy construction
- Comparative Judgments
- Synthesisof priorities

AHP can provide an analytical process that it is able to combine and consolidate the evaluations of alternatives and criteria by either an individual or group involved in decision – making task (Crouch and Ritchie, 2005).Fig. 3. represents the

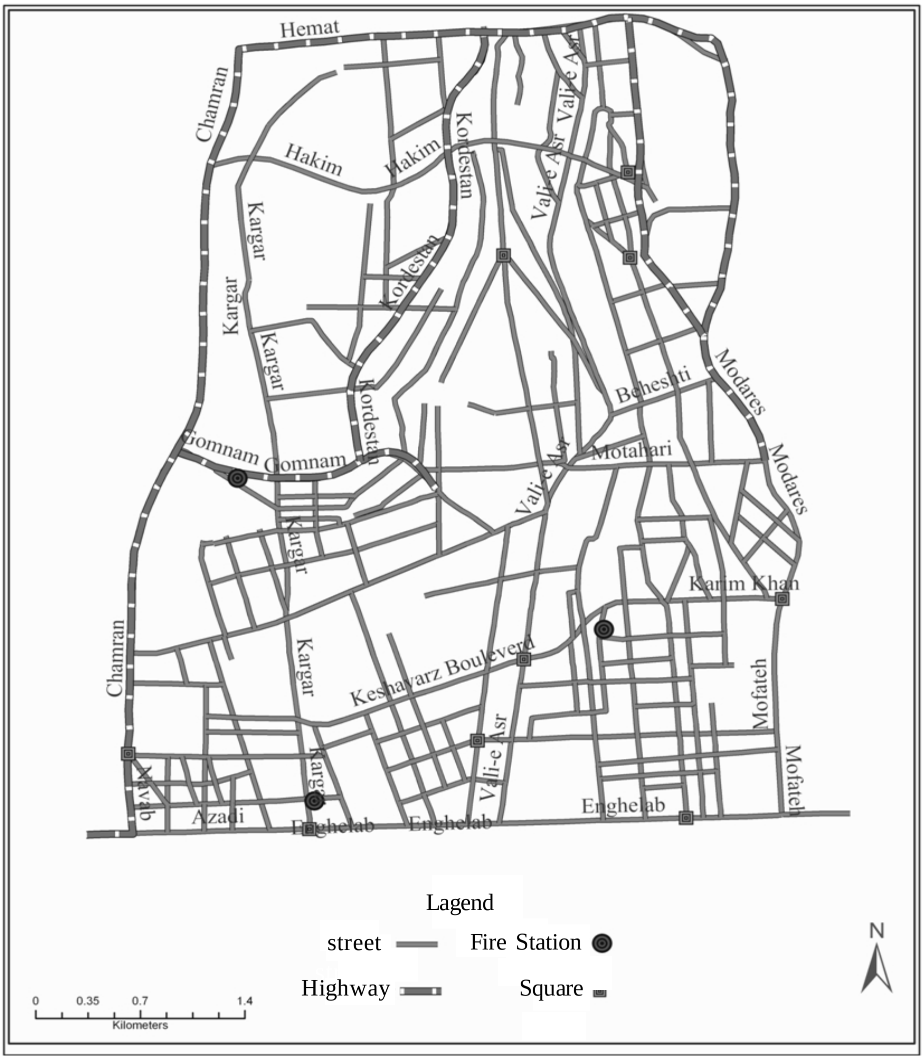

Fig . 1. Location of district 6 of Tehran in the plan of Tehran Municipal districts

Table 1. Patterns proposed for increasing access in emergencies

List	Alternative in decision-making matrix	Description of pattern features	Main feature
1	A_1	Systematically making one-way some of two-way routes	Semi-physical change
2	A_2	Constructing the continuation of present routes in north-south direction	physical change
3	A_3	Constructing new routes in north-south direction, parallel to present ones	physical change
4	A_4	Constructing new routes in east-west direction, parallel to present ones	physical change
5	A_5	Constructing the continuation of present routes in east-west direction	physical change
6	A_6	Widening present routes (in north-south &east-west directions)	physical change
7	A_7	Increasing the capacity of present routes for traffic by prohibiting on-street parking and developing parking occupancy	Semi-physical change
8	A_8	Constructing multi-level intersections	physical change
9	A_9	Usage of Intelligent traffic lights and equipment	Semi-physical change

Table 2. Indices defined for evaluating the alternatives of the matrix

List	Index code	Index definition	Index type
1	X_1	Costs	Negative
2	X_2	Effect on trip time in emergencies	Positive
3	X_3	Effect on access facilitation in emergencies	Positive
4	X_4	Length of plan execution	Negative
5	X_5	Ease of plan execution	Negative

Table 3. Multi-variable decision-making matrix

	X1	X2	X3	X4	X5
A1	1	3	3	1	9
A2	7	5	5	7	3
A3	9	9	9	9	1
A4	9	9	9	9	1
A5	6	7	7	7	4
A6	5	5	5	7	5
A7	4	3	3	5	4
A8	8	6	6	5	5
A9	1	3	1	2	9

hierarchical graph of the indices. In Table 4. after the above three-fold stages, the weight of each index is assigned by means of Expert Choice Software (ECS).

The TOPSIS is an important practical technique to solve MADM (multi-attribute decision making) problems originating from concept of displaced ideal point from which the comprise solution has the shortest distance (Zeleny, 1974). TOPSIS (the Technique for Order Preference by Similarity to Ideal Solution), developed by Hwang and Yoon (1981), is a multi-criteria decision-making (MCDM) method (Triantaphyllou and Lin, 1996). Its basic concept is that the selected best alternative from a finite set of alternatives should have the shortest distance from the ideal solution and the farthest distance from the negative ideal solution in a geometrical sense (Triantaphyllou and Lin, 1996; Olson 2004). The rating of alternative depends on the shortest distance from the positive ideal solution (PIS) and the farthest distance from the negative ideal solution (NIS). A general flow of TOPSIS involves (Fu, 2008; Fu and Yang, 2007):

Step 1: Compute the normalized decision matrix. Vector normalization is used to calculate r_{ij} (according to equation 1)

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}}, \; i = 1,\ldots, m;\; j = 1,\ldots, k-1$$

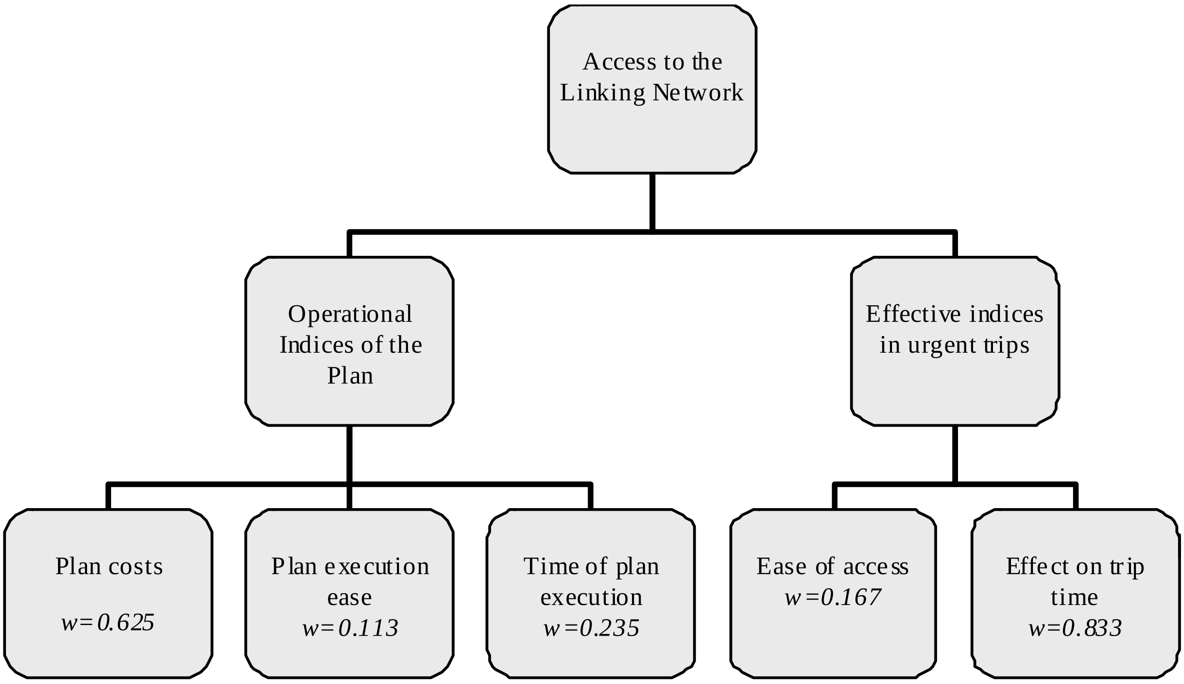

Fig. 2. The hierarchical graph used in AHP method

Table 4. Assigning weight to indices based on AHP method

	costs	Effect on trip time	Effect on access facilitation	Time of plan execution	Ease of plan execution
Final weight of indices	0.15625	0.62475	0.12525	0.05875	0.02825

- Step 2: Construct the weighted normalized decision matrix, V= $[v_{ij}\, \tilde{v}_{ij}]_{m\times n}$. The weighted normalized decision matrix is calculated by multiplying each column of the matrix by the weight (w_j), which is assigned by pair wise comparisons of elements.
- Step3: Determine the worst alternative condition (A_w) and the best alternative condition (A_b)
- Step 4: Calculate the L2-distance between the target alternative i and the worst condition A A_w

Equation 2.

$$d_{iw} = \sqrt{\sum_{j=1}^{n} (t_{ij} - t_{wj})^2}\ , i = 1,2,\ldots,m$$

and the distance between the target alternative i and the best condition A_b

Equation 3

$$d_{ib} = \sqrt{\sum_{j=1}^{n} (t_{ij} - t_{bj})^2}\ , i = 1,2,\ldots,m$$

Where d_{iw} and dib are L2-norm distances from the target alternative i to the worst and best conditions, respectively.

- Step 5: Calculate the similarity to the worst condition:

Equation 4

$$s_{iw} = \frac{d_{ib}}{d_{iw} + d_{ib}}, 0 \le s_{iw} \le 1, i = 1,2,\ldots,m$$

$s_{iw} = 1$ if and only if the alternative is in the worst condition; and $s_{iw} = 0$ if and only if the alternative is in the best condition

- Step 6: Rank the alternatives according to s_{iw} (i = 1, 2,…, m)

Steps 1 to 6 of the TOPSIS method have been taken in Table 5. The distances from the ideal and anti-ideal solution have been calculated.The sixth step of TOPSIS method has been presented in Table 6. Based on this table, A3 ranks first.

In fuzzy set theory, conversation scales are applied to transform linguistic term into fuzzy numbers. Eight conversation scales are frequently used to convert linguistics terms to fuzzy numbers (Chen and Hwang, 1992).

In this method, we used Bonison method, which defines the trapezoidical fuzzy numbers based on Fig. 3. Based on this method, 7 trapezoidical fuzzy numbers were used to convert linguistic terms to fuzzy numbers. Table 7 represents the trapezoidical fuzzy numbers corresponding to linguistic terms in a seven-fold scale.

Table 5. The distance of the alternatives from the ideal and anti-ideal solution in TOPSIS metod

Alternative	d_{iw}	D_{ib}	s_{iw}
A1	0.159329661	0.53107605	0.230777
A2	0.12898082	0.463727509	0.217613
A3	0.232706215	0.327297927	0.415544
A4	0.232706215	0.327297927	0.415544
A5	0.183845665	0.392484303	0.318994
A6	0.142157617	0.4620758	0.235269
A7	0.131312735	0.532081312	0.197941
A8	0.148590459	0.429260613	0.257143
A9	0.157651479	0.534026288	0.227926

Table 6. Ranking the alternatives by means of TOPSIS method

Rank	alternative	score
1	A3	0.41554374
2	A4	0.41554374
3	A5	0.318993763
4	A8	0.257143175
5	A6	0.235269373
6	A1	0.230776858
7	A9	0.227926191
8	A2	0.217612632
9	A7	0.19794078

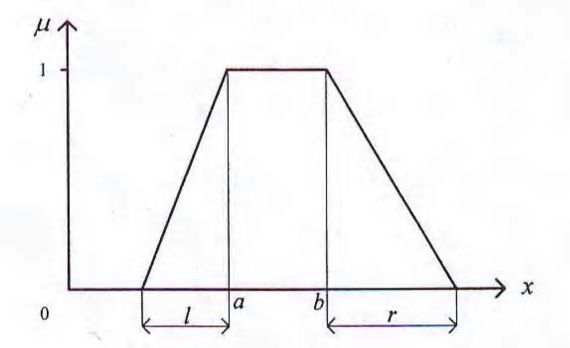

Fig. 3. Trapezoidical fuzzy numbers (Koorehpazan Dezfully, 2006)

Table 7. Trapezoidical fuzzy numbers corresponding to linguistic terms (Koorehpazan Dezfully, 2006)

Condition	Trapezoidical fuzzy numbers	Weight of index
1	(0,0,0.2)	Quite unimportant
2	(0,1,0.2)	unimportant
3	(.2,.2,.2,.2)	Rather unimportant
4	(.5,.5,.2,.2)	Neutral
5	(.8,.8,.2,.2)	Rather important
6	(.9,1,.2,0)	Important
7	(1,1,.2,0)	Very important

In this method, the preference degree of the nine alternatives has been calculated by means of the following function of preference:
Equation 5

$$U_i = \sum_{j=1}^{n} w_j r_{ij}$$

In this formula, w and r are Trapezoidical fuzzy numbers defined as (*a, b, l, r*). To convert linguistics terms to fuzzy numbers, we used the method proposed by Chen (Table 7). The values of w have been obtained from the results of AHP weight assignment (Table 4). In order to consider the weight of the indices, the quantitative values of the weights were converted to linguistic variables and then to Trapezoidical fuzzy numbers. The values of r were calculated based on Table 3. To harmonize the weight of the data, the values of the alternatives were transformed from the nine-fold scale to a seven-fold scale.(Table 8).

Table 8. Transformation of the nine-fold scale to a seven-fold scale to be used in fuzzy method

	X1	X2	X3	X4	X5
A1	7	2	2	7	7
A2	2	4	4	2	2
A3	1	7	7	1	1
A4	1	7	7	1	1
A5	3	5	5	2	3
A6	4	4	4	2	4
A7	5	2	2	4	3
A8	2	5	5	4	4
A9	7	2	1	6	7

After calculating r and w, the value of the function of preference was calculated for different alternatives by means of the arithmetical function on Trapezoidical fuzzy numbers. To calculate the weight Trapezoidical values) ($w_j r_{ij}$) of the Trapezoidical numbers w and r, we used equation 6,obtaining WR values. In this equation,

$$W = (a_1, b_1, l_1, r_1) \text{ and } R = (a_2, b_2, l_2, r_2)$$

Equation 6:

$$w.R = (a_1 a_2, b_1 b_2, a_2 l_1 - l_1 l_2, b_1 r_2 + b_2 r_1 + r_1 r_2)$$

And the sum $\sum_{j=1}^{n} w_j r_{ij}$ of the fuzzy numbers was calculated by equation 7.
Equation 7:

$$WR + WR = (a_1 + a_2, b_1 + b_2, l_1 + l_2, r_1 + r_2)$$

Having calculated the values of the fuzzy numbers, we used the mean method (Lee and Li) to defuzificate and transform fuzzy numbers to absolute numbers.The fuzzy mean of

Table 9. Results of ranking the alternatives by fuzzy method

	r	l	b	a
A1	0.9	0.26	0.72	0.5
A2	0.68	0.36	0.66	0.6
A3	0.44	0.56	1.2	1.2
A4	0.44	0.56	1.2	1.2
A5	0.78	0.58	1.07	1.06
A6	0.84	0.46	0.86	0.85
A7	0.84	0.22	0.57	0.4
A8	0.9	0.48	1.06	0.96
A9	0.7	0.26	0.61	0.5

Trapezoidical U numbers is calculated in the following way:

$$\overline{X}(U) = (-a^2 - b^2 + c^2 + d^2 - ab + cd)$$
$$/[3(-a - b + c + d)$$

Since in Bonison formula, Trapezoidical fuzzy numbers are produced in the range (r, b, a, l), and we have used the range (a, b, c, d) in Defuzzification calculations, we transformed the ranges by means of equation 10 (Fig. 4).

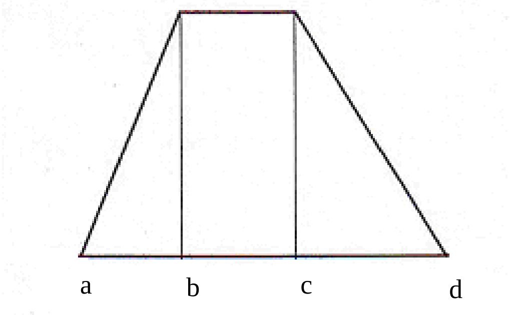

Fig. 4. Trapezoidical fuzzy numbers (a, b, c, d)

Thus, using equation 8, the values were converted and then the fuzzy mean was calculated for the alternatives.

Equation 8

$a_{ij}= b_{ij}-l_{ij}$
$b=a_{ij}$
$c=b_{ij}$
$a=b_{ij}+r_{ij}$

Having calculated the value of the absolute number for each alternative, we prioritized those with larger results. After Deffuzification, the alternatives were compared and ranked based on the resulting values (Table 9). Table 10 illustrates the conversion of Trapezoidical fuzzy numbers based on (a, b, c, and d). These numbers are displayed in Fig .4.

Table 10. Conversion of fuzzy numbers to non-fuzzy ones based on (a, b, c, d)

	a	b	c	d	mean
A1	0.24	0.5	0.72	1.62	0.832667
A2	0.24	0.6	0.66	1.34	0.767011
A3	0.64	1.2	1.2	1.64	1.433067
A4	0.64	1.2	1.2	1.64	1.433067
A5	0.48	1.06	1.07	1.85	1.242729
A6	0.39	0.85	0.86	1.7	1.058005
A7	0.18	0.4	0.57	1.41	0.694548
A8	0.48	0.96	1.06	1.96	1.242785
A9	0.24	0.5	0.61	1.31	0.727373

The SAW method is probably the best known and most widely used MADM method. A score in the Saw Method is obtained by adding contributions from each attribute.

The decision maker assigns weights w (k) to each attribute k, such that E w(k) equals 1. The aggregate utility U(i) of each alternative i is then computed as U(i) = E w(k)x(i, k), where x(i, k) is the score of the i_{th} alternative on the k_{th} attribute, with a numerically comparable scale between attributes. Alternatives are then ranked in descending order of U (i).Table 11 represents the results of pattern analysis in SAW method and their ranking.Table 12 displays the results of the comparison by means of three techniques.The results of different research models vary although in some of them, one or some alternatives may have equal ranks. They are combined in Borda method. Borda method is based on preferential majority. In this method, the results are compared in pairs.

Borda’s rule chooses each that maximizes the total number of instances in which the candidate is preferred to any other candidate. Equivalently, given p candidates, Suppose the set $A = \{a_1; a_2; . . . ; a_p\}$ of candidates (alternatives) and the profile u of the voters’ preferences are fixed.

Let $s = (s0; s1; . . . ; sp”1)$
with
$s0 = 0 \leq s1 \leq \ldots \leq sp^{-}1; sp^{-}1 > 0$
or
$s0 = 0 < s1 < \ldots < sp”1$

Table 11. Comparison of alternatives in SAW method

	X1	X2	X3	X4	X5	Sum
A1	0.008305	0.104125	0.021138	0.003079	0.015922	0.152568
A2	0.058132	0.173542	0.035229	0.021555	0.005307	0.293766
A3	0.074741	0.312375	0.063413	0.027714	0.001769	0.480012
A4	0.074741	0.312375	0.063413	0.027714	0.001769	0.480012
A5	0.049828	0.242958	0.049321	0.021555	0.007076	0.370739
A6	0.041523	0.173542	0.035229	0.021555	0.008845	0.280695
A7	0.033218	0.104125	0.021138	0.015397	0.007076	0.180954
A8	0.066437	0.20825	0.042275	0.015397	0.008845	0.341204
A9	0.008305	0.104125	0.007046	0.006159	0.015922	0.141556

Table 12. Comparison of the alternatives in three methods

	Fuzzy	TOPSIS	SAW
A1	0.6	0.23	0.15
A2	0.58	0.22	0.29
A3	0.85	0.42	0.48
A4	0.85	0.42	0.48
A5	0.87	0.32	0.37
A6	0.75	0.24	0.28
A7	0.51	0.2	0.18
A8	0.85	0.26	0.34
A9	0.52	0.23	0.14

be a system of scores, *βs* be the *scoring rule* (or *de Borda voting rule*) with scores *s*(Moulin,1988). A candidate *a* is a *winner* if *s*-Borda score *Bs (a)* is maximal.

To determine the rank in Borda method, the alternatives are compared in pairs. In comparison, if the row is preferable to the column, it will receive the M value; otherwise, or if they are equal, it will receive the X value. After marking, we count Ms and write the number in the left column. The alternative which gains a majority ranks higher.Table 13 represents the results of the combination of the methods in Borda method. In Table 14, the ranking of the alternatives is extracted based on Table 13. With regard to the results of Table 14.It is evident that the alternative 4 with seven maximum scores is considered as the alternative of highest priority. This indicates that fundamental changes in the present routes in east-west direction and constructing new parallel routes in the district are of necessity. Meanwhile, A3 pattern, which concerns the construction of north-south routes in the district, ranks second.

Table 13. Combining three methods in Borda method

	A1	A2	A3	A4	A5	A6	A7	A8	A9	M
A1	0	M	X	X	X	X	M	X	M	3
A2	X	0	X	X	X	X	M	X	M	2
A3	M	M	0	X	M	M	M	M	M	7
A4	M	M	X	0	M	M	M	M	M	7
A5	M	M	X	X	0	M	M	M	M	6
A6	M	M	X	X	X	0	M	X	M	4
A7	X	X	X	X	X	X	0	X	X	0
A8	M	M	X	X	X	M	M	0	M	5
A9	X	X	X	X	X	M	X	X	0	1

Table 14. Final ranking of the alternatives in Borda compound method

List	Rank	Alternative
1	1	A4
2	2	A3
3	2	A5
4	3	A8
5	3	A1
6	4	A6
7	5	A2
8	6	A7
9	6	A9

CONCLUSION

The results of the study indicate that the pattern A_4 with seven maximum scores is the most efficient pattern in emergency access enhancement through making changes in the route network. It is, therefore, suggested that in order to increase access in urban rescue operations, construct parallel routes in the directions of the first and second priority of east-west and north-east direction should be constructed to promote the performance of the network of the existing routes in the district in emergencies and in rescue operations.

REFERENCES

Basöz, N. and Kiremidjian, A. S. (1995). A bridge prioritization method based on transportation system performance using GIS. Proceedings of the 6th U.S.-Japan Workshop on Earthquake Disaster Prevention for Lifeline Systems, Tsukuba Science City, Japan, 437-449.

Birudian, N. (2006). Crisis management. Jahad Daneshgahi Publication, 5-11.

Burton, I., Kates, R. W., and White, G. F. (1978). The environment as hazard. New York: Oxford University Press.

Chang, S. E. and Nojima, N. (2001). Measuring post-disaster transportation system performance: The 1995 Kobe Earthquake in Comparative Perspective. **35 (6),** 475-494.

Chang, S. E., Shinozuka, M. and Moore II, J. E. (2000). Probabilistic earthquake scenarios: Extending risk analysis methodologies to spatially distributed systems. Earthquake Spectra, **169 (3)**, 281-301.

Chang, S. E., Svekla, W. D. and Shinozuka, M. (2002). Linking infrastructure and urban economy: Simulation of water disruption impacts in earthquakes. Environment and Planning B, **29 (2),** 557-572.

Chen, S. J. and Hwang, C. L. (1992). Fuzzy multipleattribiute decision making : methods and applications. Springer-Verlag , New York , 3-23.

Cutter, S. L. (1996). Vulnerability to environmental hazards. Progress in Human Geography, **20**, 529-539.

Fu, C. (2008). Extended TOPSISs for belief group decision making. J. Serv. Sci. & Management, **1**, 11-20.

Fu, C. and Yang, S. L. (2007). Soloutions to belief group decision making using extend TOPSIS. International Conference on Management Science, 458-463.

Gordon, P., Richardson, H. W. and Davis, B. (1998). Transport-related impacts of the Northridge earthquake. Journal of Transportation and Statistics, **1 (2)**, 21-36.

Crouch, G. and Louviere, G. (2005). Application of analytical hierarchy process to tourism choice and decision making : A review and Illustration applied to destination competitiveness. Tourism analysis, **10**, 17-25.

Harker, P. T. and Vargas, L. (1987). The theory of ratio scaled estimated: Satty analytical hierarchy process. Management Science, **33 (11)**, 385-403.

Karbassi, A. R., Abduli, M. A. and Neshastehriz, S. (2008). Energy saving in Tehran International flower exhibition building. Int. J. Environ. Res., **2 (1)**, 75-86.

Kates, R. W. (1996). Human adjustment. In ten geographic ideas that changed the world, edited by S. Hanson. New Brunswick, New Jersey: Rutgers University Press, 87-107.

Koorehpazan Dezfully, A. (2006). Principles of fuzzy theory and application in the modeling of water engineering problems. Jahad Daneshgahi, Amirkabir Publication, 32-69.

Lee, W. B., Lau, Z. and tam, S. (2001). A fuzzy analytical hierarchy process approaches in modular product design. Expert system, **18 (1)**, 32-34.

Li, H. X., Chen, L. P. and Hung, H. P. (2001). Fuzzy neural intelligent systems: mathematical fundamentals and application in engineering. CRC Press, New York, 4-18.

Menoni, S. (2001). Chains of damages and failures in a metropolitan environment: Some observations on the Kobe earthquake in 1995. Journal of Hazardous Materials, **83**, 101-119.

Menoni, S. and Pergalani, F. (1996). An attempt to link risk assessment with land use planning: A recent experience in Italy. Disaster Prevention and Management, **5**, 6-21.

Mitchell, J. K., Devine, N. and Jagger, K. (1989). A contextual model of natural hazards. Geographical Review, **79**, 391–409.

Moulin, H. (1988). Axioms of cooperative decision making. Cambridge University Press, 2-11.

Olson, D. L. (2004). Comparison of weights in TOPSIS models. Mathematical and Computer Modelling, **40**, 721-727.

Pourahmad, A., Baghvand, A., Zangeneh Shahraki, S. and Givehchi, S. (2007). The impact of urban sprawl up on air pollution. Int. J. Environ. Res., **1 (3)**, 252-257.

Rashed, T. and Weeks, J. (2003). Assessing vulnerability to earthquake hazards through spatial multicriteria analysis of urban areas. Int. J. Geographical Information Science, **17 (6)**, 547-576.

Triantaphyllou, E. and C. L. Lin. (1996). Development and evaluation of five fuzzy multiattribute decision-making methods. Int. J. Approximate Reasoning, **14**, 281-310.

Wakabayashi, H. and Kameda, H. (1992). Network Performance of Highway Systems under Earthquake Effects: A Case Study of the 1989 Loma Prieta Earthquake. Proceedings of the U.S.-Japan Workshop on Earthquake Disaster Prevention for Lifeline Systems. Tsukuba Science City, Japan, 215-232.

Werner, S. D., Taylor, C. E. and Moore, J. E. II. (1997). Loss estimation due to seismic risks to highway systems. Earthquake Spectra, **13 (4)**, 585-604.