Evaluation of sustainable transport strategies for Tehran with the their urbanization rate criterion based on the fuzzy ahp method

Mahsa Anbari , Ebru Arıkan Öztürk , Hakan Ateş

1 Phd. Student., Gazi University, Department of environmental and technical research of Accidents, Institute of Science and Technology, anbarimahsa@Gmail.com

2 Phd, Assistant Professor., Gazi University, Department of Traffic Planning and Implementation, Institute of Science and Technology, eozturk@gazi.edu.tr

3 Professor., Gazi University, Department of metallurgical and materials engineering, Faculty of Technology, hates@gazi.edu.tr (Technology, hates@gazi.edu.tr)

Abstract

The purpose of this study is to evaluate the sustainable transport strategies of Tehran. A hybrid method based on the fuzzy analytical hierarchy process has been used to prioritize strategies. The analytical hierarchy process is a structural method for organizing and analyzing complex decisions based on mathematics and psychology. This was developed by Thomas L. Saaty in the 1970s and has been widely studied. The designed questionnaire has 6 sections, the sections are as follows and completed by 44 experts: The main criteria are technical and technology, environment, quality, cost, administrative and organizational and time, and 4 solutions in the form of van, taxi, bus and urban train. The priority criteria are as follows: cost, quality, time, technical and technological, environment, administrative and organizational. Prioritization provided by analytical hierarchy in the form of urban train, bus, van and taxi. Considering that in developing countries, economic and financial factors are one of the main parameters affecting the entire country, the weight of this criterion is expected to be more than 34%. In the prioritization, the quality criterion is 25% in the second place, the time criterion is 23% in the third place, the technical and technological is 9% in the fourth place, the environment is 7% in the fifth place and in the sixth place administrative and organizational is 0%. The first solution is the 37% urban train and the second solution is the 18% bus, which reflects the focus on the first two solutions.

Key words: Transportation Strategies, Tehran, FAHP, Evaluation

1. Introduction

Today, in many large cities, traffic congestion, air pollution, wasting time on the route of people's daily trips, increasing fuel consumption and vehicle depreciation, etc. are among the most important challenges for urban management that of course each of which is somehow related to the growing population and, consequently, the development of cities and the imbalance between existing transportation facilities and the increasing demand for travel and travel time. In order to solve traffic problems and socio-economic and environmental problems therefrom, it is necessary to have a well-equipped and efficient public transportation system because meeting the potential demand for transportation, especially in developing countries, depends on the development of this system. A public transportation system, in terms of the number of same displaced passengers, has a lower level than a private car, and consumes less energy and less time. Therefore, in addition to being able to reduce traffic congestion, it also plays a very important role in reducing air pollution. At the same time, it is cost-effective whit less operating cost. Therefore, the public transportation system is more important as an efficient solution in this regard, which, unlike personal vehicles, it is available to all people in the community, all low-income groups benefit from it, and they also play an effective role in solving the problems caused by traffic congestion. Improving and choosing a public transportation system to improve its efficiency is a major step towards reducing travel time, and in this regard, the design of the system is in the first place. The goal of the design of a public transportation system is firstly to improve the system for existing users and, secondly, to attract personal transport passengers. The actual and potential benefits of this discussion have drawn the attention of many experts, and thus this section of transportation engineering and urban planners, along with other parts, is developing and expanding. In this regard, new types have been created which, by utilizing today's world-class technology and providing a secure, high reliability, easier, cheaper, cleaner set, have encouraged more people to use public transportation and, at top of them, fast systems which leads to become possible all or part of the benefits mentioned (Celik & Akyuz, 2018) & (Buwana, Hasibuan & Abdini, 2016).

2. Literature

Celik et al. (2018) examined AHP and Fuzzy Type 2 TOPSIS methods for decision-making problems in marine transport engineering. The duration of loading (loading or unloading) operations for ship-owners and port administrators

since the moment of unemployment in the terminal significantly increases to the cost of transportation services (Celik & Akyuz, 2018).

Azimfard et al. (2018) reviewed the selection of transportation countries for the Iranian steel industry at three levels using the AHP and TOPSIS methods. The results of this research can help steel industry managers to confront the problem of large-scale transportation choices. In addition, the approach presented in this study can help other industry managers to select and evaluate their suppliers (Azimifard, Moosavirad & Ariafar, 2018).

Soner et al. (2017) examined the application of AHP and VIKOR methods in the fuzzy 2-type environment in transport. While AHP and VIKOR provide a comprehensive framework to solve decision issues in the transportation industry, they are able to cope with the uncertainty in decision-maker language evaluation. The proposed approach is designed with the selection problem, since the structure of ships carrying porters is very important for preventing water penetration and protecting cargo from external damage (Soner, Celik & Akyuz, 2017).

Buwana et al. (2016) has reviewed alternative choices for the sustainable transport system in Kaesong. The city of Kaesong is the capital of the Kaytinan region, which has 128.906 hectares. The results of the analysis show the most suitable alternative to integrated road transport systems. Implementing this alternative by creating integrated transport locations in the city can reduce public transport users and increase CO2 emissions (Buwana, Hasibuan & Abdini, 2016).

Özkır et al. (2012) examined the fuzzy assessment framework for selecting transport investment projects in Turkey. We then recommend a fuzzy linear programming model to select the best protocol under uncertain cost. A real case study was conducted to demonstrate the effectiveness of the proposed method .(Özkır & Demirel, 2012).

Nguyen et al. (2015) have reviewed the reducing complexity of transport projects using the fuzzy analytical hierarchy process. Complexity as a criterion enables managers to anticipate the potential problems of complex transportation projects. As a result, scarce resources are thoroughly included among transportation projects within a company's portfolio .(Nguyen, Nguyen, Le-Hoai & Dang, 2015).

Odeyale et al. (2014) have evaluated the performance and selection of the best method of transportation in the metropolis of LAGOS (Odeyale, Alamu & Odeyale 2014). Despodov et al. (2011) have used the AHP method to select a transportation system in mine planning. This paper specifies the use of the AHP method in choosing an optimal transport system in a basic routing (Despodov, Mitić, & Peltečki, 2011).

Kumru et al. (2014) examined the application of the analytical hierarchy process in choosing the type of transportation for a supplies company. The results of this study indicate that rail transport, which is not widely used in Turkey, is an alternative and convenient means for transportation (Kumru & Kumru, 2014).

Kopytov et al. (2013) have investigated a multivariate selection of transport variables in the city. The presented research has shown that using global optimization criteria, one can create a global approach to the task of choosing the best alternative for different types (Kopytov & Abramov, 2013).

Ullah et al. (2018), prioritization of options for pakistan's road transport division: Multi-criteria decision analysis has been investigated. In addition to ranking and prioritizing the three fuel technologies, the results of the proposed decision framework are significant for the development of a policy on the use of various fuels in Pakistan's transport sector(Ullah, Hamid & Shakoor, 2018).

Manupati et al. (2018) have investigated a multi-criteria decision-making methodology for urban transport reconstruction in southern India. In addition, the effectiveness of the proposed method for urban reconstruction in southern India is illustrated by a real case study of life. Finally, we determine that the results will help politicians to begin urban redevelopment in southern India (Manupati, Ramkumar & Samanta, 2018).

Carli et al. (2018) have investigated multi-criteria decision making for assessing sustainable urban transport systems. Based on the characteristics of analytical hierarchy process, the results show that although a particular region is ranked in the first place, the result of maximizing the efficiency and effectiveness of measures is essential for the sustainable development of transport of energy, water and environmental systems throughout the city (Carli, Dotoli & Pellegrino, 2018).

3. Fuzzy analytical hierarchy process

The FAHP2 model provides a hierarchical structure of factors, criteria, and solutions. During the decision-making process, the joint conclusion is expressed by many experts as an optimal solution. In fact, the fuzzy analytical hierarchy process method is a combination of the fuzzy theory provided by Lotfizadeh and the gradation of Thomas Al-Saati. After completing the hierarchical structure, the criteria are ranked according to the experts and based on that a solution is presented (Bozdağ, Kahraman & Ruan, 2003).

$\tilde{A} = \{\tilde{M}_{ij}\}$ The fuzzy paired comparison matrix can be defined as 1:

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{M}_{12} & \dots & \tilde{M}_{1n} \\ \tilde{M}_{21} & 1 & \dots & \tilde{M}_{2n} \\ . & . & . & . \\ . & . & . & . \\ \tilde{M}_{n1} & \tilde{M}_{n2} & \dots & 1 \end{bmatrix} \qquad (1)$$

In this case, the relation $\tilde{M}_{ji} = 1/\tilde{M}_{ij}$ is created. Weight S_k, which is a triangular fuzzy number, is defined as:

$$S_k = \sum_{j=1}^{n} M_{kj} * \left[\sum_{i=1}^{m} \sum_{j=1}^{n} M_{ij} \right]^{-1}$$

Where j, i are solutions and k represent the row numbers of the indices.

In this method, after estimating the S_k s, their magnitude must be calculated relative to each other. If M_1 and M_2 are two triangular fuzzy numbers, the magnitude M_1 to M_2 is defined as [15]:

$$\begin{cases} V(M_1 \geq M_2) = 1 \dots\dots\dots\dots\dots\dots\dots\dots M_1 \geq M_2 \\ \\ V(M_1 \geq M_2) = hgt(M_1 \cap M_2) \end{cases}$$

And otherwise we have:

$$hgt(M_1 \cap M_2) = \frac{u_1 - l_2}{(u_1 - l_2) + (m_2 - m_1)} \qquad (4)$$

To calculate the weight of the indices in the paired comparison matrix, we perform the following:

$$W'(X_i) = \min\{V(S_i \geq S_k)\}.....k = 1,2,....., n, k \neq i \quad (5)$$

Therefore, the weight vector of the indices will be as follows:

$$W' = [W'(X_1), W'(X_2), ..., W'(X_n)]^t \quad (6)$$

Which is the same as the fuzzy AHP coefficients vector. Criteria are derived according to Equation $W_i = \frac{W_i'}{\sum W_i'}$ of updated weights (Dağdeviren & Yüksel, 2008).

4. Questionnaire

The questionnaire designed in this study has two parts, the first part containing questions such as gender, age, level of education, and so on. The second part relates to the questions of the research variables. The questionnaire with 6 main criteria and 4 strategies based on technical, economic, social and other indicators were designed to evaluate sustainable transport strategies for Tehran with the their urbanization rate criterion based on the fuzzy ahp method as Figure 1. According to the history of the studies carried out and the conditions of transportation in Tehran, 6 main criteria are suggested as follows:

- Technical & Technology
- Environment
- Cost
- Quality
- Administrative and organizational
- Time

And the four solutions are as follows:

- Bus
- Urban Train
- Van
- Taxi

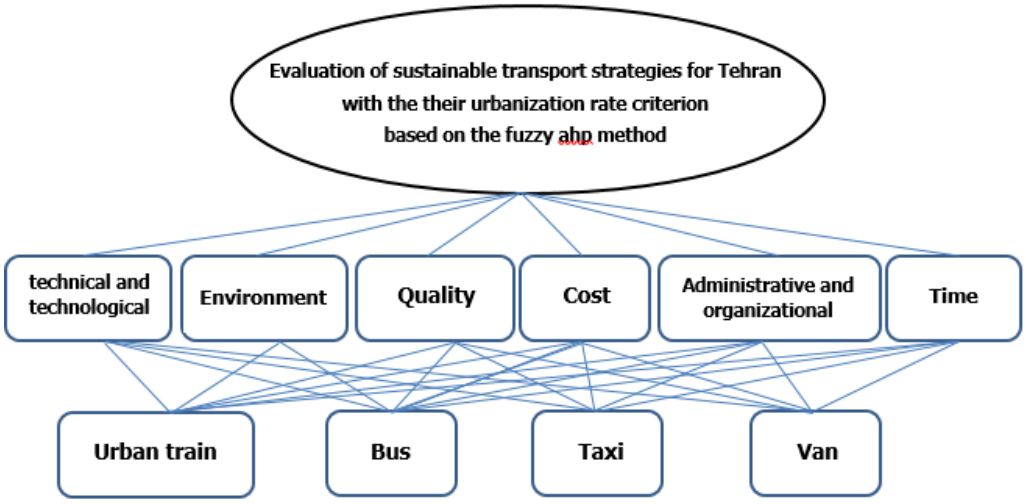

Figure 1. Research Flowchart

Statistical analysis of the questionnaire was performed using SPSS software. Due to the questionnaire has been completed by the experts, it has sufficient validity. Considering the fact that the designed questionnaire was completed by 12 people, the sample size by Cochran method was 11.66 with a 5% error rate. The observed skewness value is 0.156 and is in the range (2, 2-). That is, the questionnaire is normal in terms of tilting and its distribution is symmetric. Its elongation is 0.694 and is in the range (2, 2-). This indicates that the variable distribution has a normal elongation, and the questionnaire has successfully passed the normal test.

Table 1: Normality test of the questionnaire

Kurtosis			Skewness	
Std. Error	Statistic		Std. Error	Statistic
0.466	0.694		0.297	0.156

Descriptive frequency chart of experts based on 3 criteria of education, age and gender has been investigated. According to the experts' responses in this regard, the questionnaire has a validity. The level of education under the diploma is 30%, 20% diploma, 40% bachelor and 10% master's degree. Respondents are also 90% male and 10% female, with an average age of 47. Figure 2 shows the degree of respondents' education that shows the dark blue is diploma, the low blue color is diploma, the yellow color is bachelor's degree and the crimson color is master's degree by percentage.

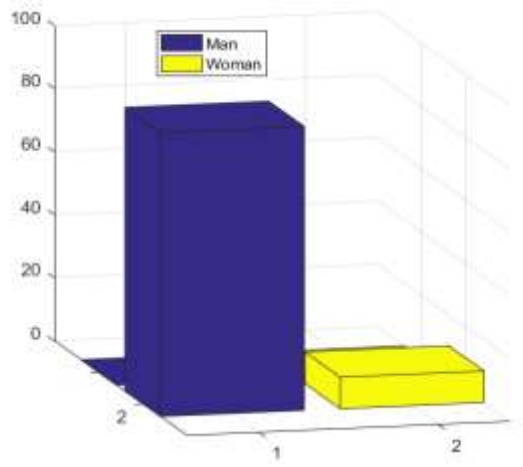

Figure 2: The degree of respondents' education by percentage

Figure 3 shows the gender of the respondents, which dark blue shows the male and yellow shows the female by percentages.

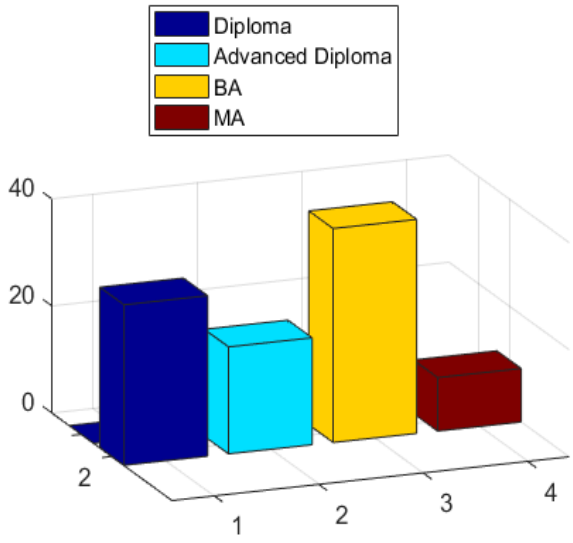

Figure 3: Percentage of respondents' gender

The reliability value is checked in the following tables.

Table 2: Reliability sub-test

Case Processing Summary			
		N	%
Cases	Valid	22	100.0
	Excluded a	0	.0
	Total	22	100.0

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.992	.993	22

In Table 2, the number of acceptable questionnaires and the number of excluded items in the sub-test have been determined. In second Table 2, the Cronbach alpha is shown and the value of 0.992 is obtained, which is obtained 0.993 after standardization.

5. The results of the study area

Tehran is the most populous city and capital of Iran, center of Tehran province and the city of Tehran. With 8,693,706 people, it is the 24th largest city in the world and the most populous city in the West Asia. Tehran's metropolis is also the third largest metropolis in the Middle East. From the administrative point of view, Tehran has been divided into 22 districts and 122 urban area and includes Tajrish and Rey. The city administration is being run by the Tehran municipality. The mayor of Tehran is elected by the Tehran City Council, and this council will legislate on the performance of the municipality supervision and city administration. In 1347, the first master plan of Tehran, with a 25-year horizon, was prepared under the responsibility of Abdul Aziz Farmanfarmaeian and Victor David Gruen, which as yet has been the most important legal basis for the development of Tehran. As a political and administrative center, the most important Iranian state and judicial institutions are located in Tehran, like the ministries and the Islamic Consultative Assembly, which this city has 30 delegates. The city has two international airports, Imam Khomeini and Mehrabad, which are

one of the most crowded airports in Iran. Tehran has a dense highway network and this network is accompanied by a large group of streets and roads. Azadegan highway is longest highway in Tehran which has 4.36 kilometers long. Personal car journeys are common in Tehran and citizens tend to use personal cars .(Dağdeviren & Yüksel, 2008). Tehran traffic is also not well-suited, and is sometimes called a crisis. After the month of October, the traffic situation of the city is usually worse due to increased student travel. The number of cars and personal vehicles in the city of Tehran is increasing and this has become one of the major problems in the metropolis (Website Tehran). According to Maziar Hosseini, a former deputy for transportation and traffic in Tehran's municipality, the number of cars in this city is about six times the capacity of its streets .(Göteborgs-Posten, 2015).

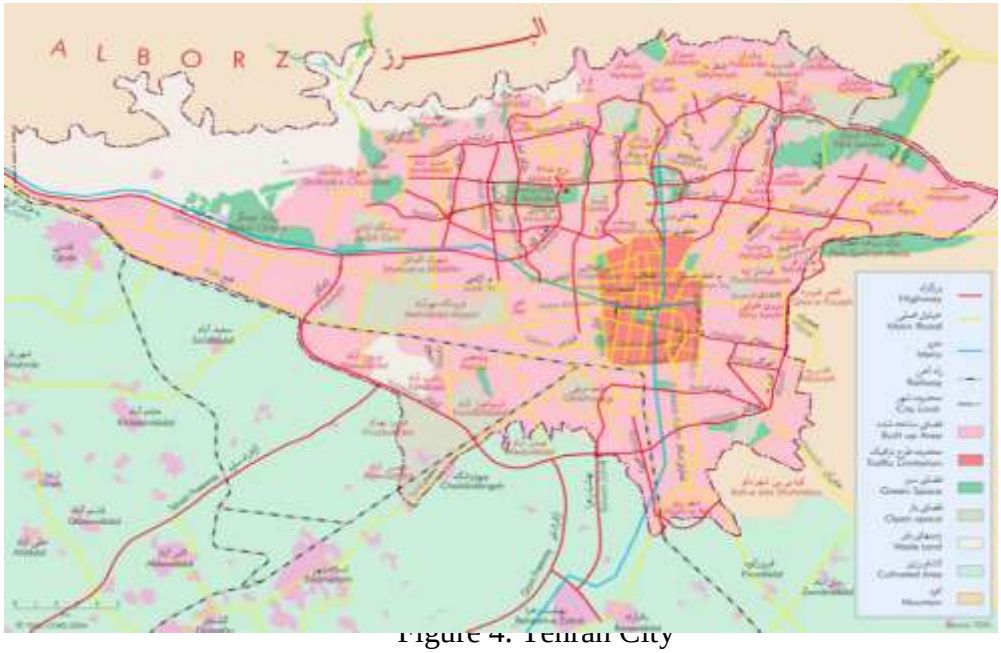

Figure 4: Tehran City

The first level of hierarchy is the main criterion. It also converts paired comparisons matrix into fuzzy triangles. The expert questionnaire first deals with the prioritizing of each of the main criteria by paired comparisons of main criteria according to the goal. Therefore, we must compare the criteria according to the two by two objective. The result of the questionnaire for the weight of the criteria is presented in Table 3.

Table 3: The paired comparisons of criteria

	time	administrative and organizational	cost	quality	environment	technical and technology	
0.098	(3,5,7)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,3,5)	(1,1,1)	**technical and technology**
0.072	(1,3,5)	(1/5,1/3,1)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)		**environment**
0.25	(3,5,7)	(1,3,5)	(1/7,1/5,1/3)	(1,1,1)			**quality**
0.34	(3,5,7)	(1,3,5)	(1,1,1)				**cost**
0.23	(3,5,7)	(1,1,1)					**time**
0	(1,1,1)						**administrative and organizational**

In this matrix, the inconsistency of 0.097 is acceptable and there is no need to revise in judgments.

According to Figure 5 and Table 3, the priority criteria are as follows:

1. Cost
2. Quality
3. Time
4. Technical and technology
5. Environment
6. Administrative and organizational

Figure 5 shows the weight of each criterion. In this figure, technical and technological, environment, quality, cost, time and administrative and organizational are 1 to 6, respectively. The highest weight belongs to the cost criterion and the lowest weight belongs to administrative and organizational criteria.

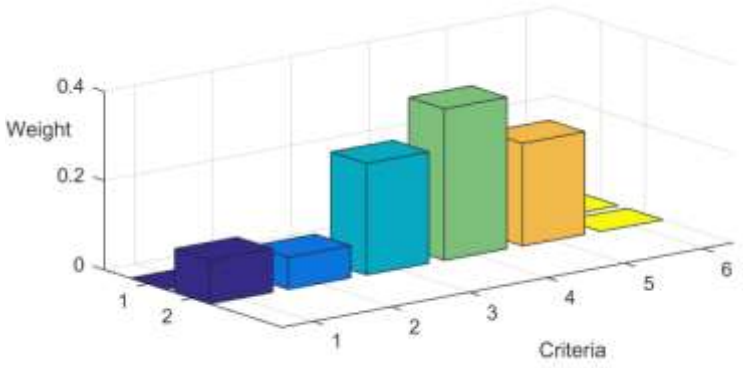

Figure 5. Weight of each criterion

The weight of each option is based on the criteria in Table 4. The criteria are C1 and C6 respectively and the solutions are A1 to A4.

Table 4. The weight of each option based on the criterion

score	C6	C5	C4	C3	C2	C1	
0.27	0.24	0.23	0.68	0.14	0.24	0.39	**A1**
0.3746	0.37	0.07	0	0.4	0.30	0.47	**A2**
0.18	0.18	0.5	0.23	0.2	0.24	0.12	**A3**
0.1242	0.18	0.2	0.07	0.16	0.20	0	**A4**

Figure 6 shows the weight of each option based on the criterion. In this figure, there are 1 to 4 solution for estimating buses, urban trains, van and taxis, respectively.

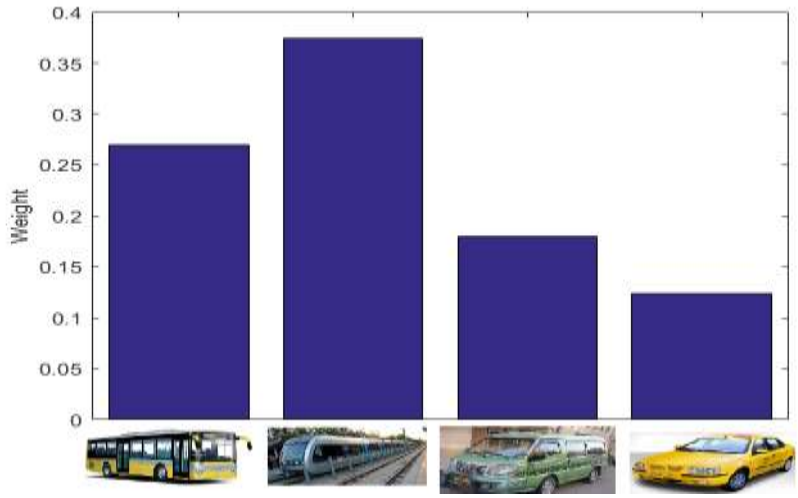

Figure 6. Weight of each option based on criterion

5. Conclusion

The purpose of this study is to evaluate the sustainable transport strategies of Tehran. A hybrid method based on the fuzzy analytical hierarchy process has been used to prioritize strategies. In this research, the evaluation of sustainable transportation strategies for Tehran with the urbanization rate based on the fuzzy ahp method has been investigated. The designed questionnaire has 6 sections, the sections are as follows and completed by 44 experts: The main criteria are technical and technology, environment, quality, cost, administrative and organizational and time, and 4 solutions in the form of van, taxi, bus and urban train. The questionnaire used for analytical hierarchy and multi-criteria decision making is called expert questionnaire. The characteristics of respondents to the questionnaire were characterized by three criteria: age, education, gender. In general, 44 respondents answered the questionnaire. Of the respondents, 27 people have a bachelor's degree of 10 people master's degree and 7 people doctoral degrees. The average age of respondents is 55 years. Of the respondents, 9 are female and 35 are male. The priority criteria are as follows: cost, quality, time, technical and technological, environment, administrative and organizational. Prioritization provided by analytical hierarchy in the form of urban train, bus, van and taxi. Considering that in developing countries, economic and financial factors are one of the main parameters affecting the entire country, the weight of this criterion is expected to be more than 34%. In the prioritization, the quality criterion is 25% in the second place, the time criterion is 23% in the third place, the technical and technological is 9% in the fourth place, the environment is 7% in the fifth place and in the sixth place administrative and organizational is 0%. The first solution is the 37% urban train and the second solution is the 18% bus, which reflects the focus on the first two solutions. The use of intelligent methods, such as artificial intelligence, can also contribute to sustained transport (Memarian Sorkhabi, 2015).

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