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CASE STUDY

Strategic planning of urban transportation system based on sustainable development dimensions using an integrated SWOT and fuzzy COPRAS approach

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ABSTRACT: Today, urban transportation has attracted urban planners' and researchers' attention because of air and noise pollution problems associated with it. In Shahrkord city in Iran, no plans have been made for sustainable transportation, and the available poor transportation infrastructure is not responsive to the growing population of the city. This issue has inflicted the city with serious problems, including environmental pollution, traffic jams, and car accidents. Therefore, it is necessary for urban managers and planners to conduct necessary planning and analysis for the development of urban transportation system through a strategic perspective. In this study, the strengths and weaknesses as well as the opportunities and threats of Shahrkord transportation system are identified using strength, weakness, opportunity, threat (SWOT) analysis. Status of the city's transportation system is determined through evaluation of internal and external factors. The results of SWOT analysis and the matrix of internal and external factors indicate that the internal and external evaluation factors are equal to 2.330 and 3.367, respectively, which means that Shahrekord transportation system holds a conservative situation. Considering the identified status, several strategies are proposed to improve the status quo. Finally, the proposed strategies are evaluated based on sustainable development indices, namely economic, environmental, and social indices, by using the fuzzy complex proportional assessment (COPRAS) method. The results show that the best proposed strategy is attraction of private investors to set up pedestrian bridges equipped with escalators and the concession of using them for the establishment of environmental advertisement.

KEYWORDS: *Complex proportional assessment (COPRAS); Strength, weakness, opportunity, threat (SWOT); Sustainable development; Urban transportation.*

INTRODUCTION

Urban transportation constitutes the main spatial structure of cities and has fundamental influences on shaping and orientation of urban development. Therefore, recognition of the trend of changes in transportation and assessment of relevant views and theories can play a significant role in the study of urban structures and the prediction of future processes in this area. This is of higher importance, especially in developing countries, such as Iran, which are experiencing the transition from traditional urbanization to modernity. In addition, this can open up new horizons and prevent repetition of the mistakes made in pioneering countries (Osorio and Chong, 2015). Today, urban transportation and traffic are among the biggest problems in human societies, especially in large cities. In order to solve this problem and its consequences, most of the urban managers and authorities have turned to using public transportation systems. Constantly, the suggestions presented to solve the urban transportation problems include

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promotion of urban infrastructure, development of universal transportation services, and modification of the urban system management. However, despite the development of these items, traffic problems and issues still remain (Farahani *et al.*, 2013; Cascetta *et al.,* 2015). Traffic, significant increase in the commuting time, increase of accidents, noise pollution, and proximity of air pollution rate to the limits of human health threats are among the consequences of unsustainable transportation systems in urban areas. Urban transportation planning refers to the continuous assessment of transportation plans to achieve the goals and objectives towards developing an urban community. In other words, transportation planning is a systematic strategy for analysis of transportation and traffic elements whose purpose is to create safety in an efficient and well-suited transportation system in connection with the current and future needs and priorities of the community (Jakovcevic and Steg, 2013; Henao *et al.,* 2015). Sustainability is not achieved solely through changes in the design, patterns of use, and management of vehicles, but some changes should also be made in the way of thinking towards the identification and evaluation of possible solutions to the problems of transportation (Cheng *et al.,* 2015). Air pollution reduction and traffic reduction are two main aspects of environmental management in sustainable transportation management. Various air pollution reduction and traffic reduction methods have been reviewed in this study. The application of e-commerce in local home shopping and its consequences on energy consumption and air pollution reduction have been investigated by Tehrani and Karbassi (2005) and Tehrani *et al.* (2009). Sekhavatjou *et al.* (2011) proposed to improve the process of catalytic reforming unit for minimizing the number of air pollutants in an Iranian old refinery. Mohammadizadeh *et al.* (2016) proposed several convenient strategies to reduce local air pollution and greenhouse gas emission in Tehran transportation system. Sustainable urban transport planning is an interdisciplinary area of research and is almost a new technical profession that has acquired groundbreaking theoretical foundations, methodological tools, and a vast interactive scope of the activities of public and private sectors (Schneider, 2013; Kim and Lee, 2014). On the other hand, the importance of transportation and its impact on economic area, social area, strategic development, policy planning, and the environment have led managers throughout the world to attempt to organize transportation in the form of integrated transportation management. In urban planning, transportation system must also be designed in harmony with sustainable development. Thus, it can be argued that one of the most important items in urban development is sustainable transportation (Beaudoin *et al.,* 2015). To date, various studies have been carried out on sustainable transportation and the assessment of its dimensions and systems. Jonsson (2008) has used cost-benefit analysis (that is to consider the monetary equivalents of all the positive and negative impacts of a project) to assess sustainability wherein the estimation of environmental and social costs is relatively difficult (Jonsson, 2008). Awasthi *et al.* (2011) used multi-attribute decision-making analytic hierarchy process to select sustainable transportation systems in imperfect information conditions. In a study conducted in the field of sustainable transportation, Bongardt *et al.* (2011) reviewed the indicators and challenges in sustainable transportation. They identified the key indicators and challenges that influenced planning and transportation strategies under the conditions of sustainable development. In a recent study, Boschmann and Kwan (2008) emphasized the social aspect of sustainable development in transportation and indicated how transportation affects social sustainability in cities. Malayath and Verma (2013) assessed the capability of travel demand models to analyze sustainable transportation policies in India. Haghshenas *et al.* (2015) analyzed the effects of transportation strategies using system dynamics model based on the data from cities around the world. In their study, nine sustainable development indices were used in three areas, namely economic, social, and environmental domains, in order to evaluate urban transportation strategies. Sayyadi and Awasthi (2017) used system dynamics to evaluate the monitoring and regulatory policies in sustainable transportation. Barrella *et al.* (2017) developed an evaluation system for sustainability evaluation, planning, and participation in the field of transportation. It was shown how decision-makers could use the developed system to improve urban development with the participation of academia. The identification and prioritization of sustainable development policies in transportation are very important (Haghshenas *et al.*, 2015). In Shahrekord, no systematic planning has been arranged in the pursuit of sustainable transportation, and the poor transportation infrastructure is not responsive to the growing population of the city. This study has been carried out in Shahrekord, Iran in 2017.

MATERIALS AND METHODS

SWOT and COPRAS methods have been used in this study for evaluation and prioritization of alternatives. The strengths, weaknesses, opportunities, and threats in Shahrekord transportation system are first identified using SWOT analysis. Then, the internal and external factors in SWOT analysis of Shahrekord transportation system are determined and, accordingly, some strategies are proposed to improve the urban transportation status. Finally, the proposed strategies are evaluated and prioritized using fuzzy COPRAS decision-making method based on sustainable development indices in three areas of economic, environmental, and social domains. Shahrekord is located in Chaharmahal and Bakhtiari province of Iran. It is the capital city and the largest city in the province, and is located 90 km away from Iran's third largest city, Isfahan (Fig. 1). Shahrekord is known for its natural environment, cold winters, waterfalls, and rivers (Wikipedia, 2017). Shahrkord is Iran's highest capital city with the height of 2,070 m above the sea level. This has led the city to be known as "Roof of Iran".

As transport systems have significant impacts on the environment, they account for 20% to 25% of energy consumption and carbon dioxide emissions in the world (World Energy Council, 2007). Thus, due to the recent transportation development in this city, this study has focused on environmental impact.

The indices of sustainable development are used in three areas of economic, environmental, and social domains to assess the proposed strategies. A model was proposed for the identification of the strengths, weaknesses, opportunities, and threats, in order to prepare the internal and external factors matrix and to evaluate the proposed strategies (Fig. 2).

SWOT Analysis

The term SWOT stands for strengths (S), weaknesses (W), opportunities (O), and threats (T), and the process of identification, evaluation, and assessment of the potentially effective internal and external variables is conceptually referred to as SWOT analysis (Pickton and Wright, 1998). SWOT analysis is a systematic analysis method for the identification of internal and external factors and strategy development in order to create the best adjustment and harmony among them. The following steps should be taken to prepare the matrix of strengths, weaknesses, opportunities, and threats (David, 2011):

1) Identification of internal factors, including the key strengths and weaknesses as well as establishment of the internal factor evaluation matrix (IFE)

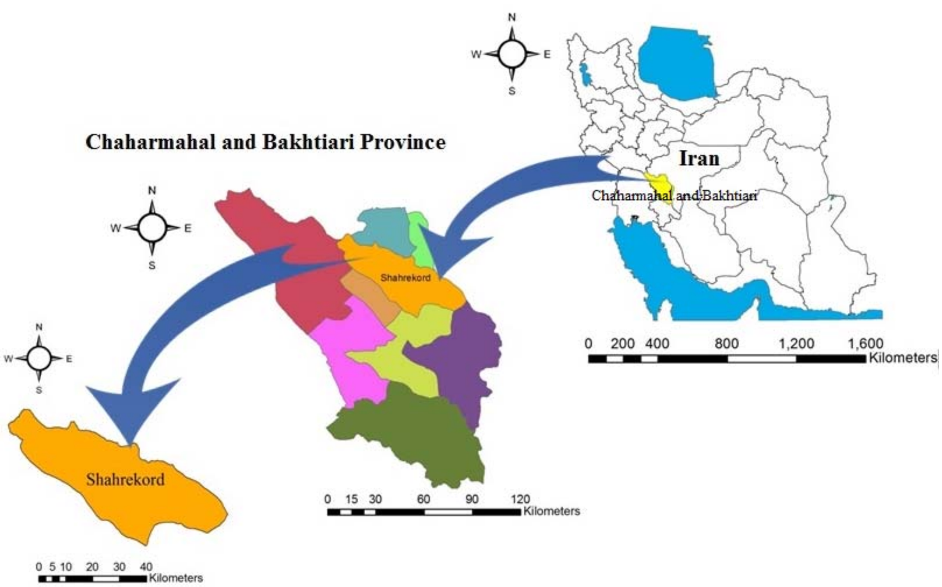

Fig. 1: The study area

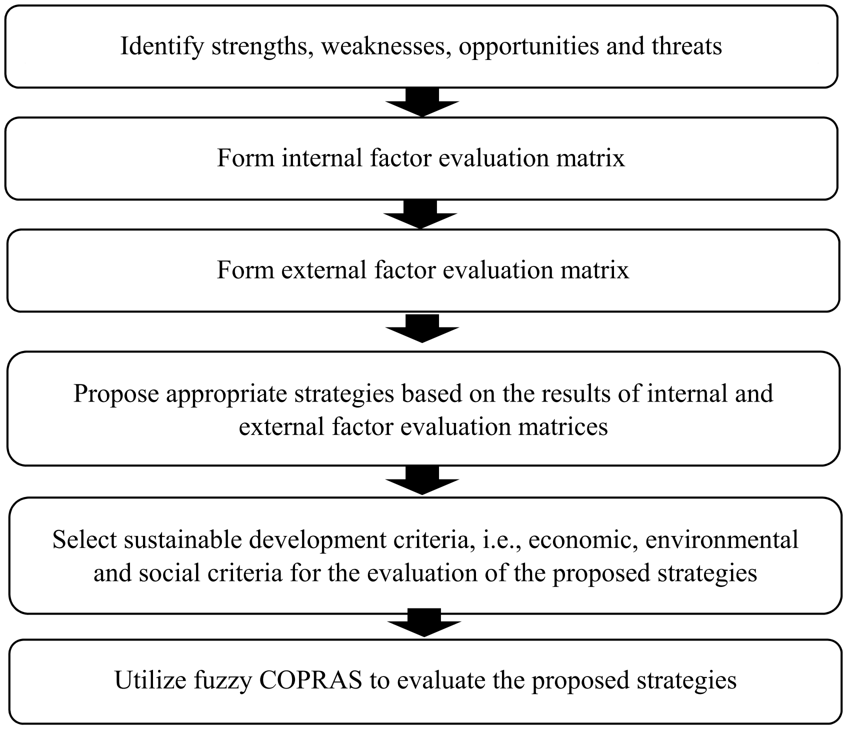

Fig. 2: The proposed model

2) Identification of internal factors, including the key opportunities and threats and production of external factor evaluation matrix (EFE)
3) Drawing the internal-external matrix
4) Development of proposed strategies using the matrix of weaknesses, strengths, threats, and opportunities (SWOT)

Using SWOT analysis, it is possible to obtain four types of strategies through the internal and external factors: aggressive strategies (SO), competitive strategies (ST), conservative strategies (WO), and defensive strategies (WT).

Fuzzy COPRAS method

COPRAS method was first introduced by Zavadskas and Kaklauskas (1996). This method introduces a solution relative to the ideal solution. COPRAS method is among the new and innovative methods for ranking, decision-making, prioritization, leveling and, in general, selection of the best alternatives, and it is applicable in all disciplines. In this method, various alternatives are evaluated independently in terms of multiple criteria and prioritized based on the objectives. Fuzzy COPRAS method is used to evaluate and prioritize the existing alternatives when there is uncertainty and ambiguity in respondents' verbal phrases. According to Yazdani *et al.* (2011), the steps of fuzzy COPRAS method are as follows:

1- Selection of fuzzy numbers suitable for the assessment of alternatives and determination of the importance of criteria

In this step, first the experts' opinions about the extent to which the criteria are met by the alternatives are collected. According to Yazdani *et al.* (2011), the linguistic variables presented in Table 1 are used to evaluate the alternatives in relation to the evaluation criteria. Rating of the alternatives is made by decision-makers according to the linguistic terms reported in Table 1. A fuzzy linguistic rating is utilized to denote the assessment of each alternative by a given criterion. In other words, Table 1 can be used to determine the score of the alternatives in relation to the sub-criteria (Yazdani *et al.,* 2011).

Table 1: Linguistic rating of alternatives (Yazdani *et al.,* 2011)

Linguistic term	Fuzzy rating
Very Poor	(0, 0, 2.5)
Poor	(0, 2.5, 5)
Fair	(2.5, 5, 7.5)
Good	(5, 7.5, 10)
Very Good	(7.5, 10, 10)

Table 2: Linguistic terms for the weight of criteria (Yazdani *et al.,* 2011)

Linguistic term	Fuzzy number
Very Low importance	(0, 0, 0.25)
Low importance	(0, 0.25, 0.5)
Medium importance	(0.25, 0.5, 0.75)
High importance	(0.5, 0.75, 1)
Very High importance	(0.75, 1, 1)

In addition, Table 2 is used to determine the importance of the criteria according to Yazdani *et al.* (2011). The importance or weight of criteria can be expressed in linguistic terms. For instance, the linguistic term "low importance" can be represented as (0, 0.25, 0.5).

2- Preparation of the fuzzy decision matrix

In this step, the fuzzy decision matrix is obtained based on the satisfaction degree of criteria by the alternatives using experts' opinions. Subsequently, the aggregated fuzzy decision matrix is obtained. It is notable that this matrix is derived from the aggregation of fuzzy decision matrices related to each expert's opinion. The geometric mean score is used to aggregate experts' opinions and to prepare the aggregated fuzzy decision matrix. It is assumed that there are *n* criteria and *m* alternatives. Accordingly, the aggregated fuzzy decision matrix is shown as follows. It should be noted that the weights of the criteria have already been calculated using the fuzzy analytic hierarchy process as Eq. 1.

$$\tilde{D} = \begin{array}{c} \begin{matrix} C_1 & C_2 & & C_n \end{matrix} \\ \begin{bmatrix} \tilde{X}_{11} & \tilde{X}_{12} & \cdots & \tilde{X}_{1n} \\ \tilde{X}_{21} & \tilde{X}_{22} & \cdots & \tilde{X}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{X}_{m1} & \tilde{X}_{m2} & \cdots & \tilde{X}_{mn} \end{bmatrix} \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} \end{array} \quad (1)$$

In the same way, it is assumed that the final weights of the criteria or the evaluation indices are as Eq. 2.

$$\tilde{W} = (\tilde{W}_1, \tilde{W}_2, \cdots, \tilde{W}_n) \quad (2)$$

At this stage, weights of the evaluation indices are defuzzified after the formation of the aggregated fuzzy decision matrix. For defuzzification of the aggregated fuzzy decision matrix and the fuzzy final weights with crisp numbers, the center of area (COA) method is used (Wu *et al.,* 2009). Assuming that $\tilde{R}_i = (L\tilde{R}_i, M\tilde{R}_i, U\tilde{R}_i)$ is a triangular fuzzy number, then, the defuzzified value is calculated as Eq. 3 according to Wu *et al.* (2009).

$$BN\tilde{P}_i = \frac{\left[(U\tilde{R}_i - L\tilde{R}_i) + (M\tilde{R}_i - L\tilde{R}_i)\right]}{3} + L\tilde{R}_i \quad (3)$$

At this stage, elements of the fuzzy decision matrix and the fuzzy weights of the criteria are converted to crisp numbers using the Eq. 3.

3- Normalization of the defuzzified decision matrix

At this stage, the defuzzified decision matrix is normalized using Eq. 4.

$$\overline{X}_{ij} = \frac{X_{ij}}{\sum_{i=1}^{m} X_{ij}}, \; i = 1,2,...,m, \; j = 1,2,...,n \quad (4)$$

Where, X_{ij} is the defuzzified element pertaining to the *i*th row and the *j*th column of the defuzzified decision matrix. Accordingly, the normalized decision matrix is as Eq. 5.

$$\overline{X} = \begin{bmatrix} \overline{X}_{11} & \overline{X}_{12} & \cdots & \overline{X}_{1n} \\ \overline{X}_{21} & \overline{X}_{22} & \cdots & \overline{X}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \overline{X}_{m1} & \overline{X}_{m2} & \cdots & \overline{X}_{mn} \end{bmatrix} \quad (5)$$

4- Preparation of the weighted normalized decision matrix

At this stage, the weighted normalized decision matrix is calculated using Eq. 6.

$$\hat{X}_{ij} = \overline{X}_{ij} \, \overline{W}_j, \; i = 1,2,...,m, \; j = 1,2,...,n \quad (6)$$

Where, $\overline{W}_j$ is the defuzzified weight of the *j*th criterion and is converted to $\overline{W}_j$.

The weighted normalized decision matrix is as Eq. 7.

$$\hat{X} = \begin{bmatrix} \hat{X}_{11} & \hat{X}_{12} & \cdots & \hat{X}_{1n} \\ \hat{X}_{21} & \hat{X}_{22} & \cdots & \hat{X}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \hat{X}_{m1} & \hat{X}_{m2} & \cdots & \hat{X}_{mn} \end{bmatrix} \quad (7)$$

5- Calculation of P_i values

The sum of P_i for benefit-based indices is calculated. These indices are of a benefit-based nature whose higher values are more favorable as Eq. 8.

$$P_i = \sum_{j=1}^{K} \hat{X}_{ij} \tag{8}$$

In the above equation, it has been assumed that the number of K criteria is benefit-based and the remaining number of *nq-K* criteria is cost-based. The cost-based indices are the ones whose lower values are more desired.

6- Calculation of R_i values

The sum of R_i for cost-based indices is calculated as Eq. 9.

$$R_i = \sum_{j=K+1}^{n} \hat{X}_{ij} \tag{9}$$

7- Calculation of the minimum value of R_i (Eq. 10).

$$R_{\min} = \min_i \ R_i ; \ i = 1,2,...,m \tag{10}$$

8- Calculation of the relative weight of each alternative Q_i

The relative weight of each alternative is calculated by Eq. 11.

$$Q_i = P_i + \frac{R_{\min} \sum_{i=1}^{m} R_i}{R_i \sum_{i=1}^{m} \frac{R_{\min}}{R_i}} \tag{11}$$

Eq. 11 can be written as Eq. 12.

$$Q_i = P_i + \frac{\sum_{i=1}^{m} R_i}{R_i \sum_{i=1}^{m} \frac{1}{R_i}} \tag{12}$$

9- Determination of optimality criterion $Q_{\max}$ (Eq. 13)

$$Q_{\max} = \max_i Q_i , \ \ i = 1,2,....,m \tag{13}$$

10- Calculation of the utility degree and priority of the alternatives

Finally, the priority of the alternatives is determined using N_i index which is the utility degree of alternative *i*. This index shows the weight of alternative *i* relative to index $Q_{\max}$. In fact, $Q_{\max}$ is a statement that indicates the maximum degree of satisfaction. The higher is the utility degree of (N_i), the higher is the priority assigned to that alternative.

$$N_i = \frac{Q_i}{Q_{\max}} 100\%, \ i = 1,2,....,m \tag{14}$$

RESULTS AND DISCUSSION

To date, no systematic planning has been made in Shahrekord city for the realization of sustainable transportation, and the weak transportation infrastructure is not responsive to the needs of the growing population of the city. This has caused serious problems, such as environmental pollution, noise pollution, traffic, accidents, etc. Therefore, the current study seeks to identify the weaknesses, strengths, opportunities, and threats in the field of transportation in Shahrekord by means of SWOT analysis and to propose some strategies for the realization of sustainable transportation accordingly. The proposed strategies would enable managers and planners to implement their short-term and mid-term plans in the pursuit of sustainable transportation. Finally, these strategies are evaluated using fuzzy COPRAS method based on sustainable development indices. The obtained results are analyzed as follows:

Identification of internal factors and preparation of the internal factor evaluation matrix

To prepare the internal factor evaluation matrix, first the most important weaknesses and strengths in the field of transportation in Shahrekord should be identified. To this end, the opinions of 20 experts and planners involved in the field of transportation in the city were collected. After the identification of the internal factors through questionnaire and collection of the experts' opinions, the impact or importance of each factor was determined. To determine the extent to which the internal factors are affected, a number between 0 and 1 is assigned to each strength and weakness in such a way that the sum of the coefficients would be equal to 1. In addition, some scores were assigned to each identified internal factor in order to determine the current status of each of them, with scores 1, 2, 3 and 4 representing basic weakness, normal weakness, normal strength, and basic strength respectively. At the end, the weighted score or the final score of each factor is calculated from the multiplication of each factor's weight by its score. Table 3 shows the weight, score, and final score of the identified internal factors.

Identification of external factors and preparation of the external factor evaluation matrix

In the second step of SWOT approach administration, the most important opportunities and threats were identified. Similarly, the most important opportunities and threats in the field of transportation were identified in Shahrekord using experts' opinions (Table 4). After identification of the external factors, the importance or the effectiveness of them and their score were determined through the same method described for internal factors. In fact, scores 1, 2, 3 and 4 represented basic weakness, normal weakness, normal strength, and basic strength, respectively. In Table 4, the most important opportunities and threats in the field of transportation along with the weight, score, and the weighted score (final score) of each factor have been presented.

Evaluation of the status of the transportation system and presentation of the proposed strategies

In this step of SWOT implementation, the best situation is selected from the quadruple situations (aggressive, competitive, conservative, and defensive), and some strategies are relevantly proposed for the improvement of sustainable transportation in Shahrekord based on the selected situation. In other words, the internal and external matrices are used to analyze the internal and external factors at the same time. The status of Shahrekord transportation system can be specified using the factors evaluation matrix. Therefore, the final scores obtained from the internal and external factor evaluation matrices are placed in the vertical and horizontal dimensions in order to formulate the matrix, determine the transportation system status, and determine the appropriate strategies. This matrix corresponds to SWOT matrix and specifies the appropriate strategies for the improvement of the transportation system. To

Table 3: Results of the analysis of internal factors (strengths and weaknesses)

No.	Strengths	Weight	Factor's score	Weighted score
1	Possibility of uniform distribution of population and construction density due to the decentralization of the checkered structure of the streets	0.060	4	0.240
2	City-wide coverage by public transportation system	0.052	3	0.156
3	Use of taxis (shuttle taxi), especially in the central regions of the city	0.037	4	0.148
4	Setting up of a new market in the body of Kashani Street, which has led to the reduction of traffic volume in the city center	0.056	3.5	0.196
5	Possibility of choosing different routes from the source to the destination due to the availability of the checkered structure of the transport network	0.086	3	0.258
6	The increased use of intra-urban intelligent transportation systems (such as electronic tickets)	0.079	2	0.158
No.	Weaknesses	Weight	Factor's score	Weighted score
1	Low permeability of the worn contexts	0.071	1	0.071
2	The vehicle-based approach in urban development and lack of attention to the walking facilities	0.088	2	0.176
3	Unwillingness of the private sector to invest and participate actively in urban transportation	0.071	2	0.142
4	Inattention to locating the attractive utilities for the population (inappropriate location of twin tower and the construction of some commercial centers in high traffic areas of the city)	0.081	2	0.162
5	Inappropriate distribution of taxi network in the city and inappropriate allocation of taxi stations	0.087	1	0.087
6	Both drivers and pedestrians' failure to comply with the traffic rules and regulations	0.081	2	0.162
7	Disorganization of the pedestrians crossing the crossroads	0.079	2	0.158
8	Small width of streets in the city center	0.072	3	0.216
	Total	1		2.330

determine the position of the transportation system, the total weighted scores of the internal and external factor matrices were extracted and drawn in the internal and external matrices. Based on the results presented in Tables 3 and 4, the total weighted scores of internal and external factors are equal to 2.330 and 3.576, respectively. These factors are drawn in Fig. 3, which is representative of the matrix of internal and external factors, along with the obtained scores. Based on Fig. 3, the status of Shahrekord transportation system has been reported to lie in the conservative domain. It is necessary to mention that if IFE<2.5 and EFE> 2.5, then the status of transportation system lies in the conservative domain, and if IFE>2.5 and EFE> 2.5, then the status of transportation system lies in the aggressive domain. Since IFE=2.330 and EFE=3.576, the situation of transportation system in Shahrekord is conservative and, hence, WO strategies can be detected to use the potential advantage of opportunities in order to compensate the weaknesses of transportation.

In the conservative position, WO strategies are the best ones for the improvement of the transportation status. In other words, the main objective in the conservative approach is to improve the internal weaknesses of the transportation system by utilizing the available opportunities. Therefore, since the transportation system in Shahrekord is placed in a

Table 4: Results of the analysis of external factors (Opportunities and Threats)

No.	Opportunities	Weight	Factor's score	Weighted score
1	Establishment of new laws and regulations at the national level to support urban transportation	0.121	4.3	0.520
2	High effectiveness of the media in changing citizens' views about traffic	0.104	4	0.416
3	Availability of a perennial approach for government organizations and agencies based on the provision of e-government services	0.086	3.2	0.275
4	Increase of fuel rates and gasoline rationing	0.155	2.5	0.388
No.	Threats	Weight	Factor's score	Weighted score
1	Failure to review and update the comprehensive urban transportation plan	0.104	3	0.312
2	Lack of the authorities' and municipalities' attention to transportation and traffic plans	0.161	3.7	0.596
3	No planning by the unified urban planning in institutions and organizations that are in charge of urban management	0.131	5	0.655
4	Further growth of private transportation facilities compared to public transportation	0.138	3	0.414
	Total	1.000		3.576

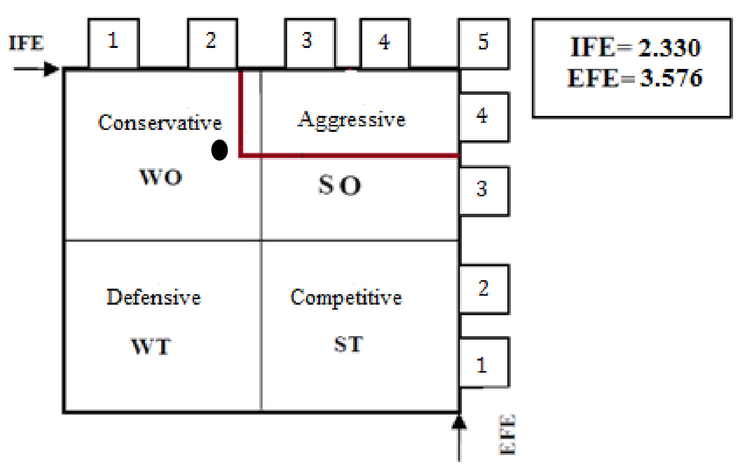

Fig. 3: Internal and external factors matrix

conservative position, the conservative strategies are extracted from the intersection of weaknesses and opportunities, as shown in Table 5. To this end, managers and city planners detected 32 WO strategies by mixing 8 weakness factors and 4 opportunity factors. However, most of these combined strategies were not attractive. Finally, the managers and city planners decided to select six relevant WO strategies for improving the urban transportation system in Shahrekord. For instance, they considered WO1

Table 5: SWOT matrix: Derivation of key strategies for urban transportation system

Internal factors \ External factors		Opportunities	
		O1	Establishment of new laws and regulations at the national level to support urban transportation
		O2	High effectiveness of the media in changing citizens' views about traffic
		O3	Availability of a perennial approach for government organizations and agencies based on the provision of e-government services
		O4	Increase of fuel rates and gasoline rationing
Weakness		Strategies on the basis of weakness and opportunities factors (WO)	
W1	Low permeability of the worn contexts	WO1	Cooperation with the Radio and Television to produce the programs that encourage the compliance with traffic regulations and increase the citizens' traffic culture level.
W2	Vehicle-based approach in urban development and lack of attention to the walking facilities	WO2	Fundraising to create park and ride at the city.
W3	Unwillingness of the private sector to investment and participate actively in urban transportation.	WO3	Attraction of private investors to set up pedestrian bridges equipped with escalators and concession of using them for the establishment of environmental advertisement.
W4	Inattention to locating the attractive utilities for the population (inappropriate location of twin tower and the construction of some commercial centers in high traffic areas of the city)	WO4	Correct and optimal use of the budget allocated for the development of transportation systems, and the use of other financing methods, such as attraction of private sector investment; conservation, restoration, and improvement of environmental capabilities; recruitment and maintenance of capital, skilled and expert human resources.
W5	Inappropriate distribution of taxi network in the city and inappropriate allocation of taxi stations	WO5	Promotion of traffic culture through some methods as teaching the students, installation of billboards and advertising banners, etc.
W6	Both drivers and pedestrians' failure to comply with the traffic rules and regulations	WO6	Stricter monitoring of the drivers' traffic behaviors that lead to the reduction of traffic congestion, pollution, fuel consumption, etc.
W7	Disorganization of the pedestrians crossing the crossroads		
W8	Small width of streets in the city center		

Table 6: Sustainable transportation criteria, their fuzzy weights, and defuzzified weights

Criteria	Sub-criteria	Type of sub-criterion	Fuzzy weight of sub-criterion	Defuzzified weight of sub- criterion
Transportation environmental criterion (C1)	Transportation pollution (C11)	Cost	(0.577, 0.758, 0.897)	0.744
	Transportation energy consumption (C12)	Cost	(0.520, 0.659, 0.752)	0.644
	Transportation land consumption (C13)	Cost	(0.214, 0.470, 0.976)	0.553
Transportation economic criterion (C2)	Transportation cost for government (C21)	Cost	(0.321, 0.476, 0.668)	0.488
	Direct trip cost for user (C22)	Cost	(0.098, 0.219, 0.590)	0.302
	Indirect transportation cost for user (C23)	Cost	(0.079, 0.185, 0.469)	0.244
Transportation social criterion (C3)	Transportation safety (C31)	Benefit	(0.552, 0.687, 0.808)	0.682
	Transportation accessibility (C32)	Benefit	(0.494, 0.625, 0.751)	0.623
	Transportation variety (C33)	Benefit	(0.369, 0.555, 0.694)	0.539

strategy which is the cooperation with the Radio and Television to produce the programs that encourage the compliance with traffic regulations and increase the citizens' traffic culture level. This strategy is obtained by combination of the sixth weakness factor (W6) and the second opportunity factor (O2). WO1 strategy uses the second opportunity (O2) to increase the citizens' traffic culture level trough Radio and Television. Therefore, both drivers and pedestrians are encouraged to comply with the traffic rules and regulations. This leads to compensation of the negative impact of the sixth weakness factor (W6).

The strategies proposed for the improvement of this system are as follows:

1) Cooperation with the Radio and Television to produce the programs that encourage the compliance with traffic regulations and increase of the citizens' traffic culture level (WO1)
2) Fundraising to create park and ride at the city (WO2)
3) Attraction of private investors to set up pedestrian bridges equipped with escalators and concession of using them for the establishment of environmental advertisement (WO3)
4) Correct and optimal use of the allocated budget for the development of transportation systems, and the use of other financing methods, such as attraction of private sector investment; conservation, restoration, and improvement of environmental capabilities; recruitment and maintenance of capital, skilled and expert human resources (WO4).
5) Promotion of the traffic culture through some methods as teaching to students, installation of billboards and advertising banners, etc. (WO5).
6) Stricter monitoring of the drivers' traffic behaviors that lead to the reduction of traffic congestion, pollution, fuel consumption, etc. (WO6).

Prioritization of the proposed strategies using Fuzzy COPRAS

Prior to evaluation of the proposed strategies, it is necessary to evaluate the criteria. As already mentioned, the sustainable transportation criteria are used to evaluate the proposed strategies. In this study, the sustainable development criteria for assessing the sustainable transportation strategies have been derived from the research performed by Haghshenas *et al*. (2015). Haghshenas *et al*. (2015) defined 9 sustainable transportation criteria which greatly cover the key aspects of urban transportation sustainability. Economic, social, and environmental impacts are the main dimensions of transportation sustainability. Environmental dimension covers transportation pollution, energy use, and land consumption. Transportation pollution indicates the annual pollution of local air pollutants per capita. Energy consumption refers to the annual transportation energy use per capita. Transportation land consumption is defined as sum of urban land area allocated to road and public reserved line. In other words, this criterion is defined as land consumption for private and public transportation infrastructures per capita (Haghshenas *et al*., 2015). Transportation cost for government, direct trip cost for user, and indirect transportation cost for user are three indicators that form the economic aspect of transportation sustainability. Transportation cost for government is the local government annual expenditures on transportation sector per GDP. Direct trip cost for user is expressed as the average user cost of one urban trip over GDP per capita. Indirect

Table 7: Aggregated fuzzy decision matrix

	C11	C12	C13	C21	C22
WO1	(6.8, 8.4, 9.6)	(3.4, 4.6, 6.2)	(4.0, 5.2, 6.8)	(3.4, 5.4, 7.0)	(4.0, 6.0, 7.6)
WO2	(4.4, 5.6, 6.8)	(5.0, 7.0, 8.2)	(5.3, 5.8, 7.8)	(3.0, 4.6, 6.6)	(4.4, 6.0, 7.2)
WO3	(6.0, 7.6, 8.4)	(2.2, 3.4, 5.0)	(1.5, 3.6, 5.6)	(4.0, 5.6, 7.2)	(4.0, 5.6, 7.2)
WO4	(4.6, 6.2, 7.8)	(1.8, 3.8, 5.8)	(7.3, 5.6, 6.8)	(2.2, 3.8, 5.4)	(3.6, 5.2, 7.2)
WO5	(5.0, 7.0, 8.2)	(4.4, 6.0, 7.2)	(5.4, 7.4, 8.2)	(4.4, 5.6, 6.8)	(4.4, 5.6, 6.8)
WO6	(3.4, 4.6, 6.2)	(1.2, 2.8, 4.8)	(1.2, 4.8, 6.4)	(3.2, 5.2, 6.4)	(4.4, 6.4, 7.6)

	C23	C31	C32	C33
WO1	(4.6, 6.2, 7.8)	(5.6, 7.2, 8.4)	(4.2, 6.2, 8.2)	(1.8, 3.4, 5.4)
WO2	(5.6, 7.6, 8.8)	(6.2, 8.2, 9.4)	(5.6, 7.2, 8.4)	(6.2, 8.2, 9.4)
WO3	(5.2, 6.8, 8.4)	(5.8, 7.8, 9.4)	(5.6, 7.6, 8.8)	(3.6, 5.2, 7.2)
WO4	(3.4, 5.0, 6.6)	(3.0, 4.6, 6.6)	(3.4, 5.0, 6.6)	(2.4, 4.0, 6.0)
WO5	(6.6, 8.6, 9.4)	(1.2, 1.6, 3.6)	(1.8, 3.0, 5.0)	(6.4, 8.4, 9.2)
WO6	(5.0, 6.6, 7.8)	(4.4, 6.0, 7.2)	(1.2, 2.4, 4.4)	(2.8, 4.8, 6.4)

transportation cost for user is defined in terms of average time spent in traffic (Haghshenas *et al*., 2015). Finally, the social aspect of transportation sustainability includes 3 indicators, namely transportation safety, transportation accessibility, and transportation variety. Transportation safety is measured in terms of annual fatality of transportation per capita. Transportation accessibility refers to the density of transportation network in an area or network length per area. This indicator is the reverse of average distance of each urban point from system network. Transportation variety is defined as the deviation of modal shares from an ideal city with equal public, private, and non-motorized modal shares (Haghshenas *et al*., 2015).

The sustainable development criteria used in this study have been reported in Table 6. The second and third columns of Table 6 show the sustainable development criteria and the corresponding sub-criteria, respectively. The fourth column of Table 6 shows the types of the sub-criteria. It is necessary to mention that according to the fifth and sixth steps of fuzzy COPRAS method, sub-criteria should be classified into two types: benefit type and cost type criteria. The benefit type is considered for those sub-criteria that satisfy the property of "the larger the better", while the cost type sub-criteria satisfy the property of "the smaller the better". The fifth column shows the fuzzy weights of the sub-criteria obtained using Table 2 and experts' opinions. First, the opinions of 20 experts about the importance of the sub-criteria were collected to obtain the related fuzzy weights, and the collected opinions were converted to the corresponding fuzzy numbers using Table 2. Then, the experts' opinions about the importance of the sub-criteria were aggregated using the arithmetic mean (Table 6). At the end, fuzzy weights of the sub-criteria were defuzzified via Eq. 3. The defuzzified weights of the sub-criteria have been reported in the last column of Table 6.

To implement the fuzzy COPRAS method, first the aggregated fuzzy decision matrix was obtained based on 20 experts' opinions. Table 1 was used to convert the experts' opinions to the corresponding fuzzy numbers. In a fuzzy decision matrix, the satisfaction rate of each sub-criterion with the alternatives is calculated based on expert's opinions. Subsequently, the aggregated fuzzy decision matrix is obtained on the basis of the calculated mean score. Table 7 shows the aggregated fuzzy decision matrix.

Matrix of the aggregated fuzzy decision is defuzzified based on Eq. 3. Moreover, the weighted normalized decision matrix is obtained using Eqs. 4 to 7, as reported in Table 8. It should be noted that the defuzzified weights of the sub-criteria, which have been reported in the last column of Table 6, are used to prepare this matrix.

Finally, using Eqs. 8 to 14 in the weighted normalized decision matrix, the following values are calculated: P_i, R_i, relative weight of the alternatives Q_i, utility degree of the alternatives $N_i(\%)$, and rank of the strategies for the improvement of the transportation status (Table 9). Based on the results

Table 8: The weighted normalized decision matrix

	C11	C12	C13	C21	C22	C23	C31	C32	C33
WO1	0.158	0.110	0.090	0.086	0.052	0.038	0.136	0.123	0.057
WO2	0.107	0.157	0.106	0.077	0.052	0.045	0.153	0.140	0.127
WO3	0.140	0.082	0.060	0.091	0.049	0.042	0.148	0.145	0.086
WO4	0.119	0.089	0.111	0.062	0.047	0.031	0.091	0.099	0.066
WO5	0.129	0.137	0.118	0.091	0.049	0.050	0.041	0.065	0.128
WO6	0.091	0.068	0.070	0.080	0.054	0.040	0.113	0.053	0.075

Table 9: Results of fuzzy COPRAS

	P_i	R_i	Q_i	$N_i(\%)$	Rank
WO1	0.315	0.534	0.770	15.96	5
WO2	0.420	0.543	0.866	17.96	2
WO3	0.378	0.465	0.900	18.66	1
WO4	0.256	0.457	0.786	16.31	4
WO5	0.234	0.574	0.656	13.61	6
WO6	0.241	0.402	0.843	17.49	3

Table 10: Qualitative comparison of the concerned researches

Reference	Type of system	Method	Results			
			IFE value	EFE value	Status of system (proposed strategies)	Ranking method
Khakpour *et al.* (2014)	Transportation System in Yazd	SWOT and QSPM	3.4	3.26	Aggressive (SO)	QSPM model
Tandiseh and Rezaiee (2014)	Urban transportation system in Mashhad	SWOT and QSPM	3.630	3.480	Aggressive (SO)	QSPM model
Rahmani and Baghbani (2015)	Transportation System in Saqqez, Iran	SWOT and QSPM	2.16	2.77	Conservative (WO)	QSPM model
Xia *et al.* (2015)	Long-Distance Passenger Transportation in China	SWOT and AHP	-	-	-	AHP model
Pazouki *et al.* (2017)	Urban environment system in Tehran	SWOT and QSPM	3.767	3.998	Aggressive (SO)	QSPM model
Martínez-Jaramillo *et al.* (2017)	Transportation system in Colombia	Simulation	-	-	Aggressive transport policies	-
Makarova *et al.* (2017)	Urban transportation system in Russia	SWOT	-	-	WO-SO-ST-WT	-
The current study	Sustainable urban transportation system in Shahrekord	SWOT and Fuzzy VIKOR	2.330	3.576	Conservative (WO)	Fuzzy COPRAS and sustainable indices

presented in Table 9, the best proposed strategy is "attraction of private investors to set up pedestrian bridges equipped with escalators and concession of using them for the establishment of environmental advertisement (WO3)." The strategy of "fundraising to create park and ride at the city (WO2)" is placed in the second priority.

A qualitative comparison is made to compare the results of this study with the previous studies. Table 10 presents the qualitative comparisons based on the type of system, the methods for strategic planning, IFE and EFE values, the system status, the proposed strategies, and the ranking methods for prioritizing the proposed strategies. Khakpour *et al*. (2014) utilized SWOT and QSPM model for the strategic planning of transportation system in Yazd. The results of their study showed that IFE and EFE values were equal to 3.4 and 3.26, respectively. It meant that the transportation status in Yazd city was in the aggressive manner. They proposed 10 SO strategies to improve the status of transportation system and prioritized them using QSPM model. According to Table 10, SWOT and QSPM are considered as the strategic planning methods in most of the studies, while SWOT and fuzzy COPRAS are applied in the present study. Furthermore, this study prioritized the proposed strategies based on the transportation sustainable dimensions.

CONCLUSION

Considering the importance of sustainable transportation, SWOT analysis and fuzzy COPRAS method were used to identify and evaluate the appropriate strategies for the improvement of the status of transportation system. To this end, the strengths, weaknesses, opportunities, and threats of the transportation system in Shahrekord city were identified. Then, the situation of the transportation system was determined through evaluation of the internal and external factors. The obtained results showed that transportation system in Shahrekord was placed in a conservative position. Accordingly, conservative strategies were proposed to improve the status of the transportation system via integration of the weaknesses and opportunities. The criteria for the sustainable development of transportation were used to evaluate the proposed strategies. A total of three economic, environmental, and social criteria and nine sub-criteria were selected for the evaluation of the proposed strategies. Finally, fuzzy COPRAS method was used to evaluate and prioritize the proposed strategies based on the sustainable development criteria. The obtained results showed that the proposed strategies of "Attraction of private investors to set up the pedestrian bridges equipped with escalators and concession of using them for the establishment of environmental advertisement" and "fundraising to create park and ride at the city" were placed in the first and second rankings, respectively.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

ABBREVIATIONS

%	Percent
COA	Centre of area
COPRAS	Complex proportional assessment
EFE	External factor evaluation
Eq.	Equation
GDP	Gross domestic product
IFE	Internal factor evaluation
m	Meter
N_i	Utility degree of alternative *i*.
O	Opportunity
P_i	Sum of attribute values for benefit type criteria of alternative *i*.
Q_i	Relative weight of alternative *i*.
R_i	Sum of attribute values for cost type criteria of alternative *i*.
S	Strength
SO	Strength and Opportunity
ST	Strength and Threat
SWOT	Strength, Weakness, Opportunity, Threat
T	Threat
W	Weakness
WO	Weakness and Opportunity
WT	Weakness and Threat

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