Journal of Ferdowsi Civil Engineering, Vol.34, No.3, 2021.

Prioritization of Traffic Congestion Control Strategies in Metropolitan Areas (Case Study: Mashhad)

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1. Introduction

Today, one of the most important issues in urban management is controlling traffic congestion and reducing its negative effects, especially in the central areas of cities. Traffic congestion control strategies can be divided into two general categories: strategies based on increasing supply and strategies based on reducing demand. Demand-based strategies take precedence over supply-based strategies. The main methods of implementing policies based on reducing traffic demand that has been used so far in different cities of the world are: creating a restricted traffic area, traffic congestion pricing, and turning traffic plan (even and odd plan). The purpose of this study is to identify and rank the effective criteria for evaluating traffic congestion control strategies in metropolitan areas and to rank these strategies based on the selected criteria. The study area in this study is the metropolis of Mashhad.

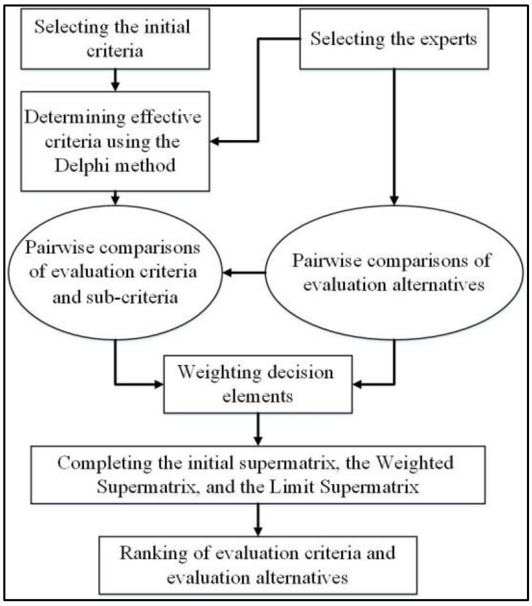

Figure 1. The flowchart of evaluation steps

2. Method

The selected method for evaluating traffic congestion control strategies in this study is the hybrid method of Delphi and Analytic Network Process (ANP). In the first step of this hybrid method, effective criteria in evaluating traffic congestion control strategies are identified and determined using the Delphi method and based on the opinions of experts. These criteria are then used in the Analytic Network Process (ANP) method to rank the evaluation alternatives. Figure 1 shows the flowchart of evaluation steps.

In the Delphi method, the basic criteria are scored by experts according to their degree of importance and effectiveness. Then, the criteria whose average score is higher than the threshold in the Delphi method (0.7) are selected as effective criteria. In Analytic Network Process (ANP), decision elements including criteria, sub-criteria, and evaluation alternatives are compared by experts in each of the three categories in the pairwise form. The final pairwise comparison matrices are obtained by geometric averaging of experts' scores. The initial weights of the decision elements in each of the final pairwise comparison matrices are then calculated using Equations (1) and (2). In these Equations, a_{ij} is the abnormal component and r_{ij} is the normal component of the pairwise comparison matrix, and W_i is the weight of element i in the corresponding pairwise comparison matrix.

$$r_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \quad i,j=1, 2,\dots, n \qquad (1)$$

$$W_i = \frac{\sum_{j=1}^{n} r_{ij}}{n} \quad i,j=1, 2,\dots, n \qquad (2)$$

The initial supermatrix is then formed based on the initial weights of the decision elements, and the weighted supermatrix and the limited supermatrix are calculated using Super Decisions software. The decision elements are ranked based on the final weights obtained from the limited supermatrix.

3. Results

Initial sub-criteria were classified into four categories: the criteria of social comfort, traffic operation, safety, and environment (Table 1). The effective evaluation sub-criteria were determined

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according to Table 1 using the Delphi method.As can be seen, the sub-criteria of car accidents, pedestrian and bicycle accidents, and noise pollution were removed from the initial sub-criteria. As a result, the safety criterion was also removed from the evaluation criteria.

Table 1. Criteria and sub-criteria for evaluating traffic congestion control strategies in metropolitan areas

Initial criteria	Initial sub-criteria	Average scores	Accept / Reject
Social comfort	Travel time	0.93	Accept
	Travel cost	0.80	Accept
	Accessibility	0.76	Accept
Traffic performance	Using of public transport	0.79	Accept
	Single-occupancy vehicles traffic	0.85	Accept
	Driving violations	0.74	Accept
	Operating speed	0.76	Accept
Safety	Car crashes	0.50	Reject
	Pedestrian and cyclist accidents	0.65	Reject
Environment	Air pollution	0.74	Accept
	Noise Pollution	0.61	Reject

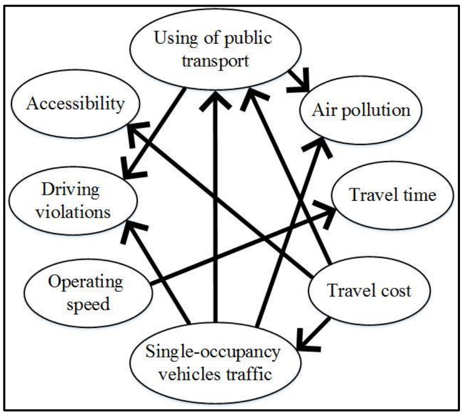

Figure 2. Considered Dependencies between the elements of the decision

The existing dependencies between the evaluation sub-criteria were identified based on the experts' opinions according to Figure 2. Then, by performing pairwise comparisons of decision elements based on experts' opinions and extracting the final matrices of pairwise comparisons in the Analytic Network Process (ANP), the initial weights of decision elements were determined and entered into the initial supermatrix. Then, the weighted supermatrix and the limited supermatrix were calculated by the Super Decisions software, and the final weights of the decision elements were determined by the limited supermatrix. After normalizing the final weights of the decision elements, the sub-criteria and evaluation alternatives were ranked according to Figure 3 and Figure 4, respectively.

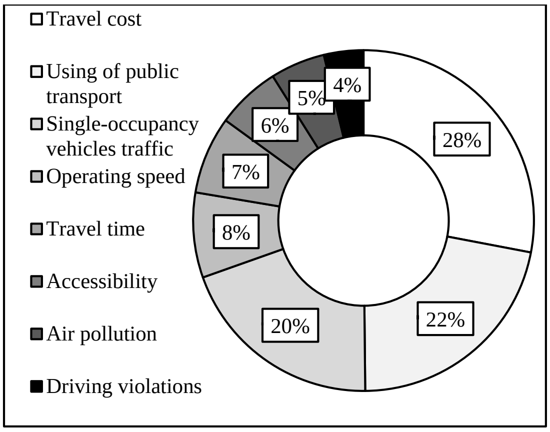

Figure 3 Ranking of sub-criteria of traffic congestion control strategies evaluation in metropolitan areas

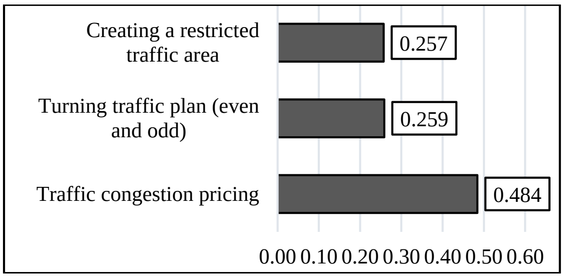

Figure 4 Prioritize traffic congestion control strategies in metropolitan areas

4. Conclusion

Based on the research conducted in this article, the following results were obtained:

- The most appropriate traffic congestion control strategy in metropolitan cities is the traffic congestion pricing strategy. The strategies of turning traffic plan (even and odd plan) and creating a restricted traffic area were also in the second and third priorities, respectively.
- The final score of the turning traffic plan is almost equal to the final score of the plan of creating a restricted traffic area, which indicates the inefficiency of the turning traffic plan (even and odd plan) in controlling traffic congestion in the metropolis of Mashhad.
- The indicators of travel cost, using of public transportation, and single-occupancy vehicles traffic were recognized as the most important effective indicators in evaluating traffic congestion control strategies, respectively.