



## Determining the Best Path for Bicycle Lane Construction Using Sustainable Transportation Approach (Case Study: District 1 of Shiraz)

M. Habibian<sup>1\*</sup>, P. Hamouni<sup>2</sup>, P. Haghshenas<sup>3</sup>

<sup>1</sup> Transportation Planning, Amirkabir University of Technology (Tehran Polytechnic), Tehran, Iran

<sup>2</sup> P. Hamouni, Civil Engineering, Concordia University, Montreal, Quebec, Canada

<sup>3</sup> Urban Planning, Islamic Azad University Central Tehran Branch, Tehran, Iran

**ABSTRACT:** Nowadays, cycling is considered as a solution to address traffic congestion problem and its consequences, especially air pollution. However, this mode requires suitable facilities including bicycle paths. This paper discusses prioritizing of five bicycle paths in district 1 of the city of Shiraz, Iran, regarding “Safety”, “Appeal” and “Mobility” criteria. The safety criterion is subcategorized into five factors as follows: number of street crossed by the path (i.e., intersections), slope of the path, heavy vehicles in the path, speed limit of the path and number of direction offsets along the path. The criterion of appeal of the path is subcategorized into two factors as follows: attractiveness of the path sides and the diversity of land uses along the path and at last, the mobility of path is subcategorized into number of public transit stations along the path, residents alongside the path and educational centers along the path. Based on the Analytical Hierarchy Process (AHP), the weights of criteria and factors demonstrate that according to transportation experts’ opinions, the most important factors were slope and speed limit of a path. Furthermore, the application of the method in one of the districts of the city of Shiraz has been conducted.

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### 1- Introduction

The widespread automobile usage in large cities has had several negative consequences such as traffic jam and environmental pollutions. To cope with the mentioned problems, Transportation Demand Management (TDM) policies which are aimed at more efficient use of transportation resources are suggested [1]. Nowadays, transportation policies are addressed through an approach called sustainable transportation, which organizes principle for sustaining finite transportation resources necessary to provide for the needs of future generations [2]. Therefore, in order to mitigate traffic congestion; several solutions have been proposed such as bicycle usage as a transportation mode. One of the policies which have been taken place in a number of cities with traffic congestion is providing a bicycle network. Providing an appropriate bicycle path is one of the effective factors for cycling improvement. For example, it has been found that the presence of bicycle lanes or paths directs cyclists onto certain routes [3, 4].

Safety-related factors (e.g., width of curb lane, sidewalk width, speed limit, pavement quality and curb activity disturbance), mobility related factors (e.g., population and number of schools in the bikeway), appeal-related factors (e.g., recreational area and aesthetics) and socioeconomic-related factors (e.g., income repartition, crime concentration,

and presence of illegal districts near the bikeway), play an important role in bicyclists’ tendency to use bicycle lanes. Furthermore, one may expect that the significant factors are varying among different cities. In this study, the prioritization of proposed bicycle paths in district no. 1 of the city of Shiraz, Iran, has been conducted using the AHP method excluding socioeconomic factors due to the lack of data. There have been an increasing number of studies focusing on cyclists’ preferences for choosing a path [5], [6]. However, these studies were mainly focused on cyclists’ behavior regarding their path choice and users’ opinion rather than experts’ opinion. This paper stresses on experts’ choice rather than cyclist preferences.

### 2- Methodology

To develop a ranking framework in this paper, the Analytical Hierarchy Process (AHP), which is used to determine the relative weight of criteria and factors, is adopted [7, 8]. It is worth noting that this method is enhanced by the scoring method to assess a score to each of the studied factors for a path. Therefore, the resulted methodology provides quantitative values to evaluate paths, which provides a measure for ranking of the available candidate road segments/paths.

After defining the problem and the related criteria/factors, AHP consists of four steps as follows: The first step is hierarchical sorting of factors and criteria. On the second

Corresponding author, E-mail: habibian@aut.ac.ir

step, a set of comparison matrices, A, which indicates criteria's/factors' preferences, is generated. This comparison is done through several pair-wise comparisons between each criterion's factors and between the criteria. On the third step, the weight of each criterion/ factor is determined as a column vector, w, which can be referred to by its transposed vector as:

$$w^T=(w^1, w^2, \dots, w^n) \quad (1)$$

Saaty showed that w is the eigenvector of the greatest eigenvalue of matrix A which is indicated by  $\lambda_{max}$  [7] as presented by equation (2):

$$Aw=\lambda_{max} w \quad (2)$$

As comparison of all criteria/factors is a confusing situation, the precision of responses should be controlled. Therefore, in the fourth step, in order to investigate the consistency of responses, a ratio called Consistency Ratio (CR) is introduced for each respondent (equation 3). CR is equal to Consistency Index (CI) divided by Random Index (RI):

$$CR = \frac{CI}{RI} \quad (3)$$

Assuming m criteria/factors, CI, for an m\*m matrix is defined as equation (4):

$$CI = \frac{\lambda_{max} - m}{m - 1} \quad (4)$$

Criteria and factors were chosen based on measurability, availability of respective data, cyclists' need and role in sustainable transportation. Criteria were defined as "safety of the path", "appeal of the path" and "mobility of the path". To increase precision each criterion consists of a number of factors where each of which could be subcategorized into some sub-factors. The safety criterion is subcategorized into five factors as: number of street crossed by the path (i.e., intersections), average slope of the path, heavy vehicles passing through the path, speed limit of the path and number of direction offsets along the path. The criterion of appeal of the path is subcategorized into two factors as follows: attractiveness of the path sides and the diversity of land uses along the path and at last, the mobility of path is subcategorized into number of public transit stations along the path, residents alongside the path, and number of educational centers along the path.

### 3- Case study and Results

In this paper, district no. 1 of the city of Shiraz is chosen as a study area. The area of no.1 district of Shiraz is 4235 hectares and its population in 2011 was 212491 [9]. Based on a former study [10], five distinct paths were reported as feasible paths for the studied district. It is concluded that the path named "1" ranks the first in the safety and mobility criteria, and the last in the appeal criterion. Due to the derived weights, path "1" stands on the highest rank of construction. Other studied paths are ranked as "4", "5", "2" and "3", respectively. The paths are shown in Figure 1.

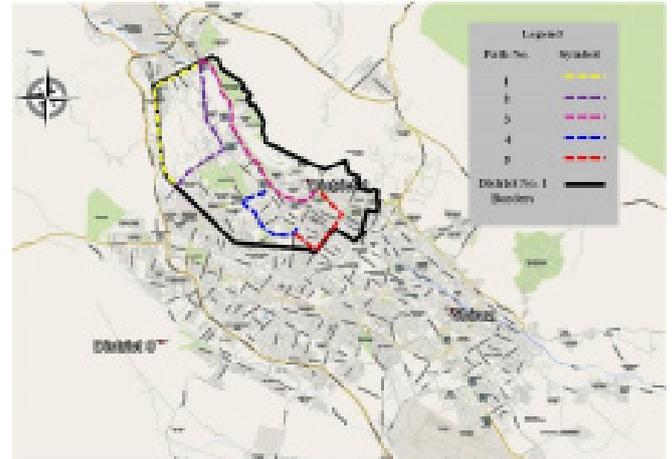


Figure 1. Proposed bicycle paths

### 4- Conclusion

The results demonstrated that according to transportation experts of the study, the most significant factors are slope of the path and speed limit on the path. Additionally, the least important factor is number of educational centers along the path.

The safety criterion accounts for 75% of importance. This result indicates that implementing measures addressing this criterion can have a significant impact on path's rank. As conclusion, special care should be taken for flat feasible paths where the traffic speed is reasonably low.

Results also showed that appeal criterion accounts for about 15% which is more affected by the attractiveness of the path sides. Therefore, it can be expected that the green space highly affect this criterion. Furthermore, the mobility criterion plays a weak role in the allocation of money for constructing bike lane. It is worth noting that the results derived by this study are highly affected by the group of the experts. Therefore, more studies suggestible to confirm the derived weights. Furthermore, recruiting more disciplines (e.g., urban design and urban planning) among experts in order to more comprehensive viewpoint in decision making is suitable.

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