Sigma J Eng & Nat Sci 7 (1), 2016, 89-96

Publications Prepared for Transist 2015,
8th International İstanbul Transport Congress
Transist 2015, 8. Uluslararası İstanbul
Ulaşım Kongresi için Hazırlanan Yayınlar

**Research Article / Araştırma Makalesi**

# INVESTIGATING THE EFFECTIVE PARAMETERS OF SAFE BICYCLE ROUTE BY USING A SURVEY STUDY

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**Received/Geliş: 24.02.2016 Accepted/Kabul: 04.06.2016**

**ABSTRACT**

This study provides an overview of effective parameters for safe cycling by carrying out a survey on five hundred participants who have been cycling for a long time and 26 of them are the members of a cycling associationin Isparta City. Additionally, sample applications of effecting parameters for safe cycling routes have been examined. Parameters effective for selecting safe cycling paths have been determined by evaluating the literature research and weights of the effects have been obtained by analyzing the survey results.
Literature studies showed that separated bicycle lanes, road grades, bicycle accident prone locations, bicycle lane markings, bicycle parks on their way, come across to a bus stop, vehicle road side parking, and location of bus lines are respectively important effective factors for selecting bicycle route. These safety parameters are weighted with Analytic Hierarchy Process. Furthermore, importance of safe and appropriate bicycle route planning highly recommended to the cities which have not seen cycling as a mode of transportation yet.
**Keywords:** Safe bicycle route, survey, analytic hierarchy process.

**GÜVENLİ BİSİKLET GÜZERGAHI SEÇİMİNDE ETKİLİ PARAMETRELERİN ARAŞTIRILMASI**

**ÖZ**

Bu çalışma, uzun zamandır bisiklet kullanan ve 26'sı Isparta şehrinde bir bisiklet derneği üyesi olan beş yüz katılımcıile bir anket çalışması yapılarak güvenli bisiklet sürüşü için etkili parametreler hakkında genel bir bakış açısı sağlaması için yapılmıştır. Çalışmada ayrıca,güvenli bisiklet güzergâhları için gerekli parametrelerincelenmiştir. Parametreler,literatür taraması yapılarak belirlenmiş ve ağırlıkları anket sonuçları analiz edilerek elde edilmiştir.
Literatür taraması, bisiklet rotası seçiminde önemli faktörlerin sırasıyla anayollardan ayrılmış bisiklet şeritleri, yol eğimi, bisiklet kaza riski olan kesimler, bisiklet şeridi işaretlemeleri, bisiklet park yeri, otobüs durağı yakınlığı, yol kenarı motorlu taşıt parkı ve otobüs duraklarının konumları olduğunu göstermiştir. Bu güvenlik parametrelerinin Analitik Hiyerarşi Yöntemi ile ağırlıkları atanmıştır. Ayrıca, bisikletin henüz bir ulaşım modu olarak kullanılmadığı kentlerdegüvenli ve uygun bisiklet güzergâhı planlamasınınönemi ve gerekliliği üzerinde durulmuştur.
**Anahtar Sözcükler:** Güvenli bisiklet güzergâhı, anket, analitik hiyerarşi yöntemi.

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## 1. INTRODUCTION

Cycling is a valid method for travel in short distances and a safe transportation mode at urban areas, when there are appropriate bicycle paths or lanes. Over the past years, Turkey has got experience in cycling on the purposes of recreation, health and transportation. Cycling provides an opportunity for exercising, which is necessary for good health [1]. Many commuters have found cycling as an option to avoid traffic congestion and parking difficulties.

Increasing at global problems like climate change, the peak in petroleum production, traffic congestions and road safety has encouraged sustainable transportation systems like walking, cycling, public transit, green vehicles, and car sharing [2]. Applications that give priority to automobiles instead of pedestrians and cyclists have not only affected physical environment but also affected social and cultural communication of the community, safety due to traffic accidents and human health because of polluted air. When it is considered in terms of environmental, economic and social sustainability, gas emissions and the use of non-renewable fuels affecting the environment negatively have to be minimized, the use of energy and time costs lost in traffic and costs of traffic accidents have to be minimized and accessibility has to be provided for everyone in a sustainable transportation system. Unsustainability is caused due to preferring policies supporting automobile use and based on vehicle traffic. Though transportation is not to transport vehicles from place to place but to transport people from place to place. These policies caused global, urban and local problems. Therefore, in recent years, it has been tried to support sustainable non-motorized modes of transport.

Cycling is defined under the title “non-motorized modes of transport” (also called “active transport”) and bicycle lanes and roads have been constructed in many cities in the world. Cycling is being supported for being an important transportation alternative that gives people chance to exercise regularly. Bicycle parking lots have been constructed especially in public transport stations to increase the use of bicycles and it has been tried to integrate public transport with cycling.

Besides, some municipalities with advanced bicycle path infrastructure have provided bicycle rental services for free and let cyclists to carry their bicycles during their trips in a mode of public transport.

Within the scope of this study, effective parameters’ weights for safe cycling have been investigated by carrying out a survey evaluating the results by using Analytic Hierarchy Process. Besides, safe cycling and safe bicycle route selection applications have been examined. Importance of integration of public transport with cycling has been underlined. Safe and appropriate bicycle route planning recommended to the cities in which the importance of sustainable transportation has not quite been implemented yet.

## 2. SAFE CYCLING ROUTE PARAMETERS

Ensuring the safety of cyclists is an important necessity for supporting and increasing the use of bicycles. Cyclists are legitimate users of the roadway. The importance of cycling characteristics on any bicycle facility has been understood and there are many parameters that affect safe cycling.

One of the most important reasons why people don’t cycle is the unsafe bicycle routes. In inner Sydney, more than 50 % of people say they would ride a bike to work at least once a week if they could use a bicycle way that is separated from motor vehicles. American Journal of Public Health (2012) indicated that bike lanes reduce the risk of injury by 50 % while dedicated bike lanes reduce it by 90 % [3]. So, the number of injuries involving people on bicycles has decreased where separated bicycle ways are built.

20 % of the League of American Bicyclist members were surveyed about their cycling experiences like bicycle type and equipment, purposes of bicycle trips, total distance, accidents

etc. Study was unique for including crash rates based on distance. Moritz (1996) showed that roads with bike lanes are safer than those without [4].

A survey that carried out by Embarq Türkiye (2014) showed that the most important problem was collisions with motor vehicles with significance level of 58%. Whilst the situation of lack of continuity of bicycle-dedicated roads had significance level of 57 %, problem of unsafe roads had significance level of 44,5 %. Other problems are the difficulty of crossing an intersection, conflicts with other cyclists, and inadequate infrastructure [5].

The required width for a safe cycling is the sum of the width of the cyclist and the width of operating or maneuvering a bicycle [1]. Figure 1 shows space dimensions required for a safe maneuvering. Embarq Türkiye's survey showed that while attendees were asked about their ideas about the importance of road safety conditions, ensuring enough widths of bike paths were the most important recommendation with the importance level of 77,5 % . Other recommendations were the requirement to develop the traffic signs (53,5 %), requirement to forbid parking of the motor vehicles on bike paths (51,5 %), applying proper lighting, using proper pavement material, and designing bike path suitable for the type of the road [5].

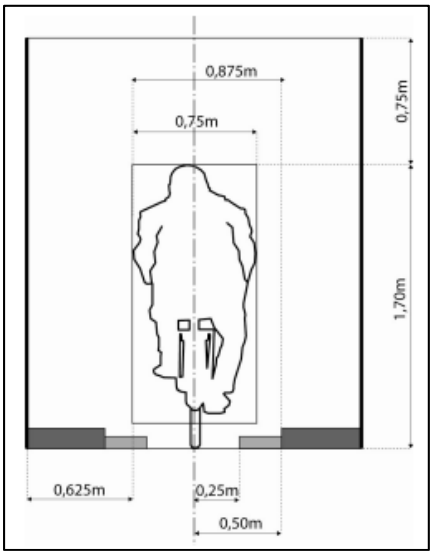


**Figure 1.** Required Space for Cyclists [6]

A typical bicycle in the United States is 1,75 m in length with a handlebar width of 0.6 m. In the Netherlands, it has been reported that 95 % of bicycles are less than 1,9 m in length and that 100 % of bicycle handlebar widths are less than 0,75 m. In Germany, it has been reported that 1 m is the normal width of one bicycle lane. In Sweden, 1,2 m is reported as a typical bicycle lane width. A Chinese study reports that the width of a two-lane bicycle path in China is generally 2,5 m with an additional 1 m added for each additional lane. The Norwegian Public Roads Administration indicates that "one meter is not enough" and recommends a width of 1,6 m for single-lane bicycle lanes [6]. In Turkey, the bicycle lane standard is 1.3 m with 0.5 m safety distance for one way bicycle lane on pedestrian road or 1.1 m with 0.5 safety distance for narrow pedestrian road and 2.4 m with 1.5 safety distance for two way bicycle road near highway [7].

A satisfactory cycling route has to be uninterrupted and has following criteria: safe, direct, cohesive, comfortable and attractive [8]. Also the parking bicycle area is important for safe bicycling. According to a survey carried out by Embarq – Türkiye (2014), it was indicated that %

79,3 of 150 attendees had never used bicycle parking lots. 16,1 % of those who had used parking lots emphasized that they had had problems while using them. Parking lots located in an unsafe area, lack of security system with camera and lack of sufficient parking lot are the problems experienced. 41,9 % of attendees who are aware of bicycle parking lots thought that parking lots were sufficient [5].

Another bicycle route safety parameter is using bicycle with the other transportation modes, especially bicycle integration with public transportation. Integrating public transport with cycling provides travelling from door to door, increases the potential destinations for cyclists, allows cyclists to be protected from unsafe traffic and increases exercising.

Cycling – public transport integration includes allowing bicycles on public transport like bus, rail, ferry etc., and/or constructing storage for bicycles. According to a study in New Zealand, it has been indicated that the more cycling is integrated with public transport services, the easier it becomes for people to combine cycling and public transport on a single trip [9].

According to a survey carried out in Australia [10], there are many improvements needed for integrating cycling with public transport. More than 80 % of the attendees found "more room for bikes on trains" implementation very useful. Also, approximately 80 % of them wanted a "booking system to ensure that bicycle will be carried on train or coach" implementation. Furthermore, more than 70 % thought that "ability to travel with bicycle on coach" and "better cycling network" are important improvements.

In the Netherlands, an improved storage system is being used by thousands of commuters. There are 93 cycle stations with an average of 1,000 bicycles bicycle spaces, but in some cases up to 10,000. Therefore, in comparison to Denmark with 25 %, Sweden with 9 %, 39 % of the clients of trains in the Netherlands use their bicycles to get to the train station [11].

In Copenhagen on S-trains and in Berlin on S-Bahn and U-Bahn, cyclists are allowed to get their bicycles on board. Copenhagen S-train network (S-tog) has started free bicycle carriage since 2009 and number of people who use S-tog has tripled from 2,1 million to 7,3 million [11, 12]. Debrezion et al. (2009) found that presence of parking spaces and bicycle standing areas had a positive effect on the choice of accessing departure railway stations [13, 14]. Integration between bicycling and public transporting has been increased up to 45 % in the Netherlands [15]. This integration makes various means of transport more attractive and comfortable. It also provides an alternative to automobile usage. Improving bicycle – public transport connection encourage cycling as a part of transportation.

Literature studies showed that separated bicycle lanes, road grades , bicycle accident prone locations, bicycle lane markings, bicycle parks on their way, come across to a bus stop, vehicle road side parking, and location of bus lines are respectively important effective factors for selecting bicycle route. So in our study it is tried to find what are the weights of all these parameters for selecting a bicycle route.

## 3. RESEARCH METHODOLOGY AND FINDINGS

This study aims to emphasize the importance of determining safe cycling route parameters. A web-based survey particularly provided to determine how can be the safe and convenient bicycle paths and which effective factors are important for this routes.

The survey has put into practice for 500 people willing to ride a bike that are selected from students and staff of Suleyman Demirel University. 69 % of them are composed of individuals at the age between 20 and 30 while 23 % of them are at the age between 31 and 40, 2 % of them are at the age between 0 and 19, only 5% of them are at the age between 41 and 50, 1% of them are at the age between 51 and 60. Regarding the results, there are no participants aged 60 or over. Also %26 of them are members of a bicycle association in Isparta city.

The participants are asked questions to the weights of effecting factors for bicycle route safety. Firstly, while performing the survey, each bicyclist is asked for choosing one of the scales

1, 3, 5, 7, (1: equal, 3: moderate importance, 5: strong importance, 7: very strong importance). Effecting factors, gathered from questions are given in Fig. 2. How many participants in the survey give more importance to these factors are analyzed by using Analytic Hierarchy Process (AHP) and route selection parameters have been weighted according to the results. Also, Fig. 2 shows all scores given to the factors.

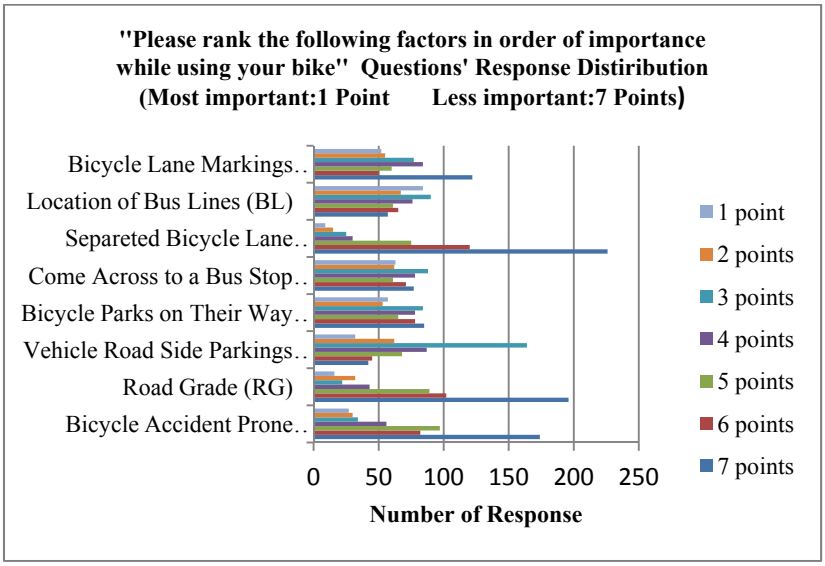


**Figure 2.** The Percentages of Responses Given for the Suitable and Safe Bicycle Routes

Admittedly, assessing all factors by examining scores together without grouped for safe and suitable bicycle route from the survey data is difficult because the scores that given to the factors are complicated as depicted in Figure 2. Whereas, it is possible to separate the problem into goal, criteria, sub-criteria and alternatives to evaluate all factors clearly by using Analytical Hierarchy Process (AHP). Thus, AHP is selected for evaluating the results of how many participants in the survey give more importance to these factors.

AHP, developed and refined by Saaty on 1970 [19] has become one of the most effective multi-criteria evaluation methods that have found uses in a wide range of practical applications in a variety of decision making processes [20]. It allows decision makers to model the problem in a hierarchic structure that shows the relations between the main goal of the problem, criteria and alternatives.

While analyzing with AHP, firstly the hierarchy is built with respect to their impact on an element above them in the hierarchy. After pair wise comparison is made, comparison matrix is gathered. Table 1 reports the pairwise comparison scale used in the AHP developed by Saaty (1977) is used for converting the importance of effecting factors' judgements into numerical values and for computing the priorities of the elements. [16].

**Table 1.** AHP Pairwise Comparison Matrix for Criteria [17, 18]

| | Criteria 1 | Criteria 2 | … | Criteria n |
|---|---|---|---|---|
| Criteria 1 | W1/W1 | W1/W2 | … | W1/Wn |
| Criteria 2 | W2/W1 | W2/W2 | … | W2/Wn |
| : | : | : | : | : |
| Criteria n | Wi/W1 | Wi/W1 | … | Wi/Wn |

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & \dots & \dots & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & \dots & \dots & \dots & a_{2n} \\ \vdots & \vdots & & & & & \vdots \\ \vdots & \vdots & & & & & \vdots \\ \vdots & \vdots & & & & & \vdots \\ \vdots & \vdots & & & & & \vdots \\ a_{n1} & a_{n2} & \dots & \dots & \dots & \dots & a_{nn} \end{bmatrix}$$

In AHP while making the comparisons, the decision makers can use concrete data about the elements, but they typically use their judgments about the elements' relative meaning and importance [19]. So the finding values are scaled based on expert opinions that are taken form twenty five experts, study on bicycle road safety in different European Countries by using web survey. While developing Table 2, the scales of 1 to 9 are given for finding the importance of matrix criterias as Saaty (2008) suggested [19]. Then values of parameters are normalized and weights of criterias are determined. The super matrix is weighted by the eigenvectors that are obtained by MatLab software and results are given in Table 2.

**Table 2.**Weights of Effecting Parameters for Bicycle Route Selection

| | |
|---|---|
| Separated Bicycle Lane (SBL) | 0,35 |
| Road Grade (RG) | 0,25 |
| Bicycle Accident Prone Location (BAPL) | 0,18 |
| Bicycle Lane Markings (BLM) | 0,07 |
| Bicycle Parks on Their Way (BP) | 0,06 |
| Come Across to a Bus Stop (BS) | 0,04 |
| Vehicle Road Side Parking (VRSP) | 0,03 |
| Location of Bus Lines (BL) | 0,02 |

It can be emphasized that separated bicycle lane is the most convenient and safe factor because according to the weights of the criteria Separated Bicycle Lane (SBL) has the highest weight. Furthermore, it has been understood that road grade is a big problem among the bicyclists. The criteria of Road Grade (RG) and Bicycle Accident Prone Locations (BAPL) rank among second and third place.

## 4. CONCLUSION AND RECOMMENDATIONS

This study has been carried out in order to determine positive effects on safety of bicycle route selection. It was difficult to find which route can be chosen for safe and suitable bicycling because of the lack of database.

A survey has been carried out on 500 people. Results have been evaluated to have an idea about safe cycling route which bicyclists prefer to use; they are given eight parameters to range them about their safety and route selection.

Survey results are showed that separated bicycle lane is the most important factor for bicyclists to select a route, the others are: Road Grade, Bicycle Accident Prone Location, Bicycle Lane Markings, Bicycle Parks on Their Way, Come Across to a Bus Stop, Vehicle Road Side Parking, and Location of Bus Lines.

It is certain that there must be a bicycle route selecting data system in urban areas. To make it possible, in future studies, a spatial data and map system like Geographic Information System can be used. Also bicycle-car accident prone locations can be taken into consideration for selecting safe bicycle routes. The other result is, bicycle-public integration must be supervised for safe bicycle routes.

In order to contribute to future studies, from this study it is understood that in this kind of making planning decisions of bike routes, spatial data and analysis (for example Geographic Information System approach) should be used for more accurate results.

**Acknowledgement / Teşekkür**

The study was funded by the SuleymanDemirel University Scientific Research Project Coordination Unit Project 3414-YL1-13 and connected to cooperation with COST Action Project TU1101**:** Towards Safer Bicyclingthrough Optimization of Bicycle Helmets and Usage. We would like to thank COST Action Project TU1101-Work Groups; Isparta Police Department and Isparta Municipal Traffic Office.

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