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CYCLISTS' REAL PERCEPTION OF ROAD AND TRAFFIC CONDITIONS: THE ESTIMATION OF BICYCLE LEVEL OF SERVICE MODEL

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Abstract

Understanding how to perceive the risk of riding based on real perceptions of cyclists is crucially important for promoting cycling as a sustainable form of transport. Previous researches have mainly used video simulations to survey riders about their riding behaviours and to gauge their perceptions about safety and their comfort level. Thus, the objective of this study is to identify the factors that significantly affect the comfort perception of the cyclists and to create a new Bicycle Level of Service model for urban street segments based on real perceptions of cyclists. This is especially the case for urban street segments in cities carrying heterogeneous traffic and without distinct segments of bicycle paths. The present paper describes, various operational and physical factors along with user perception data sets were collected from 13 road segments in the city of Pristina. For the estimation of a mathematical model for the Bicycle Level of Service, a linear regression model was used. Regression analyses are used in order to explain a dependent variable based on the relationship between a set of independent variables. Each of the data sets were entered one at a time into the statistical analysis package SPSS and the regression model was modified throughout the process by inserting all possible variables, running the regression and then examining the t-statistic for each of the variables. The resulting BLOS model has shown a high reliability for its applications in the urban street segments and has reported a high correlation coefficient (R) of 0.758 and

small statistical error. Incorporating outputs of the regression model, a predictive equation is presented that can identify under what level a segment is offering services for bicycle use. This paperwork can serve the planners when developing urban planning to consider the need for creating the infrastructure for cyclists and safety conditions for accommodating cyclists in the urban road network.

Keywords-Bicycle Service Level, real perception of cyclist, safety, comfort.

INTRODUCTION

In the last decades, European Countries are paying particular attention in undertaking proper planning and developing the traffic for cyclists. Compared to other cities in Europe, the traffic for cyclists in the city of Pristina has not been treated properly. The low level of use of bicycles is also connected to weak urban planning which is pertaining almost two last decades in the city of Pristina. During this period, road infrastructure planning and construction has been mainly focused in addressing topics of motorized vehicles without taking into consideration what are requirements and needs for active movements. Recent data available on daily transport of passengers in Pristina city show that there is only 1% of traffic conducted by bicycles [1]. The problem is not only in absence of cyclists' lanes but also in narrow and overloaded lanes for motorized vehicles. As regards special lanes dedicated to cyclists there is a problem which associate with them and that is the mentality of vehicle drivers and passengers. Based on online survey in which 1579 respondents participated, only 1.25% of them stated they use bicycle as principal way of movement in the city of Pristina. Surveys conducted to households regarding safety of movement by bicycles in road, show about 39.1% of respondents who consider that bicycle traffic is dangerous in the road network of Pristina. Nevertheless, about 53.6% of respondents stated they are willing to use bicycles like transportation manner with condition of cyclists' infrastructure and safety improvement.

The criterions of service level for drivers, cyclists and pedestrians is relied on various parameters, therefore calculation is also done based on various input data. The level of service for vehicles is primarily depended on the speed, movement and traffic constrains, while calculation of the service level for cyclists is done taking into account safety, convenience and comfort. As regards urban circumstances, Bicycle Level of Service (BLOS), is addressed for parts of roads and for intersections. Davis (1987) developed the Bicycle Safety Index Rating (BSIR) which itself contains two sub-models, one for roadway segments and one for intersections the safety of

roadway segments depends on traffic volume, outside lane width, speed limit, pavement condition, and geometric factors [2]. Safety factors which have an impact in the roadway segments depends on traffic volume, speed limit, outside lane width, pavement condition, and a variety of geometric factors. Nevertheless, safety factors which have an impact in the intersections depends on traffic volume, the type of signalization, and several geometric factors. Harkey et al (1988) developed a Bicycle Compatibility Index (BCI) for suburban and urban roadways at midblock locations [3].

The methodology used in obtaining the perspectives of bicyclists in this study consisted of having participants view numerous roadway segments captured on videotape and rate these segments with respect to how comfortable they would be riding there under the geometric and operational conditions shown. Landis et al. (1997) have developed a Bicycle Level of Service (BLOS) model for roadway segments by having bicyclists ride selected roadway segments on a real-life course and provide comfort and safety ratings on a scale of A through F [4]. Botma (1995) proposed service level methodologies for bicycle paths and bicycle pedestrian paths. The most current version, the HCM 2016, has included a multi-modal service level (MMLOS) method for urban streets. The MMLOS framework takes into consideration the perspectives of motor vehicle drivers, pedestrians, bicycles and transit users on different types of transportation facilities including intersections and urban streets [6]. One of the key features is that it integrates the effects of motor vehicles on pedestrians and bicyclists. For bicycles this latest edition emphasizes BLOS measures of cycling comfort based on the quality of bicycle facilities and the speed and density of motor vehicle traffic next to the facilities. The sole model in Europe which addressed bicycle service level is developed by Jensen (2007). The results provide a measure of how well urban and rural roads accommodate pedestrian and bicycle travel [7]. Until 2004, many attempts at developing a LOS standard have been made for describing urban traffic, but no research has specifically focused on describing rural bicycle traffic. Therefore, the sole model dealing with bicycle service level on rural conditions is developed by Jones (2004). The Rural Bicycle Compatibility Index model (RBCI) was developed using modern technology such as digital video, the Internet, and server based surveying techniques, to allow subjects to view roadways that they may have never seen or ridden on, and then assign a rating to those roadways based on the representative conditions that they saw presented [8].

METHODS AND DATA COLLECTION

The data for this study is collected in Pristina city which is the capital of Kosovo. The population of Pristina is around 200 000 inhabitants [9], which when taking into account Pristina district, the population is calculated to be around 500 000 inhabitants. Data for this study are collected on 13 roads with mixed traffic of the road network of Pristina by various characteristics of roads and traffic (Fig.1).

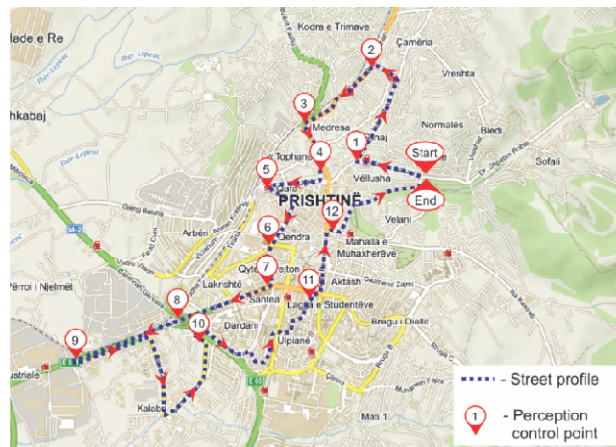


Fig.1. Cyclists paths through roads on which the research is conducted

74 respondents participated in this research and each of them gave an approach for these thirteen roads. Face to face questionnaires contributed in regard to key factors which have an impact in safety and commodity when riding bicycles in the roads. Gender representation in this research is 68% male and 32% female. Questionnaires are compiled with intention to get perceptions of respondents on main factors which have an impact on road traffic safety. Questionnaires apart including data on age and gender contained also questions on their experience of respondents about driving. These questions closely match those used in the BCI survey [9, 10]. The questionnaire is divided into three main fields. The first one is about demographic data relating to the age and gender. The second field is about respondents' experience on riding bicycles. The last field of the questionnaire through Likert scale (1-6), is about the impact of key factors on road bicycle riding safety.

IDENTIFICATION OF KEY FACTORS THAT AFFECT BICYCLE SERVICE LEVEL

The number of possible factors was initially selected based on previous studies conducted so far related to the impact of these factors on the use of bicycles. Then, the number of key factors has been revised by different focus groups. Focus groups were mainly small groups, who made the assessment of the factors according to certain criteria, taking into account the particular experience, attitudes and special experience in the areas of transport and cycling. Therefore, this type of survey does not result in statistically significant data, but can be useful when collecting qualitative information [12].

Based on the discussions it is estimated that for the needs of this study will be analysed the impact of the road characteristics, traffic and environmental infrastructure. (Table 1).

Table 1. Roadway and traffic characteristics for bicycling

Thematic categories	Attributes
Traffic characteristics	- Traffic volume - Vehicle speed - Heavy vehicles
Road characteristics	- Right-hand width - Pavement surface condition - The presence of Cycle Lane - Physically separated bicycle paths - The presence of on-street parking
Environmental characteristics	- Climatic conditions

With intention to establish mathematical model for assessment of Bicycle Level of Service, database is established based on the research conducted on thirteen various roads of the road network in Pristina city. After assessment within groups, selected factors are reflected in the following figure 2.

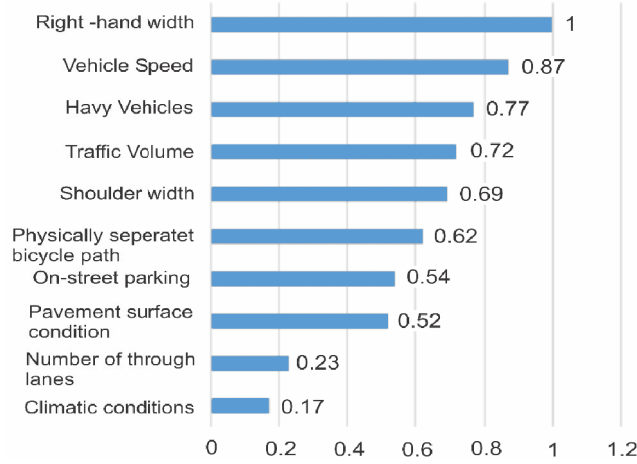


Fig.2. Values of attributes in the interval 0-1

REGRESSION ANALYSIS TO DEVELOP BICYCLE LEVEL OF SERVICE MODEL BASED ON REAL PERCEPTION OF CYCLISTS

Establishment of model is done applying stepwise regression analysis. There is strong correlation between independent variables which conditioned modelling through some variants of combined variables.

Using linear regression, the model is as follows:

$$BLOS = b + a_1(BrV) + a_2(V) + a_3(SK) + a_4(BT) + a_5(FBT) + a_6(P) + a_7(KU) \quad (1)$$

Due to testing of variations, the most appropriate way of regression equation is as follows:

$$BLOS = b + a_1[f(BrV)] + a_2[f(V)] + a_3[f(SK)] + a_4[f(BT)] + a_5[f(FBT)] + a_6[f(P)] + a_7[f(KU)] \quad (2)$$

Establishment of model is done applying stepwise regression analysis. There is strong correlation between independent variables which conditioned modelling through some variants of combined variables. Table 2 contains four out of many models for which coefficients have been tested.

Table 2- Variants for establishment of model using stepwise regression analysis

Model Coefficients and Statistics								
Coefficients ^a								
	Model	Unstandardized Coefficients		Standard Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-6.343	.328		-19.348	.000		
	Traffic Volume $\ln(\text{Vol}_{15}/L)$	2.642	.081	.785	32.620	.000	1.000	1.000
2	(Constant)	-3.435	.323		-10.631	.000		
	Speed and HV $\ln(S(1+HV))$	1.613	.091	.479	17.742	.000	.554	1.803
	Pavement Condition $(PC)^{-2}$	8.055	.475	.458	16.965	.000	.554	1.803
3	(Constant)	-4.094	.326		-12.565	.000		
	Traffic Volume $\ln(\text{Vol}_{15}/L)$	1.496	.089	.444	16.746	.000	.535	1.868
	Pavement Condition $(PC)^{-2}$	6.439	.513	.366	12.551	.000	.443	2.259
	Speed and HV $\ln(S(1+HV))$	.242	.034	.180	7.013	.000	.571	1.750
4	(Constant)	-4.406	.329		-13.393	.000		
	Traffic Volume $\ln(\text{Vol}_{15}/L)$	1.585	.090	.471	17.539	.000	.509	1.964
	Pavement Condition $(PC)^{-2}$	5.987	.516	.340	11.599	.000	.425	2.351
	Speed and HV $\ln(S(1+HV))$	.298	.036	.222	8.206	.000	.503	1.990
	Effective width of outside lane $(We)^2$	-.021	.005	-.096	-4.429	.000	.785	1.275

a. Dependent Variable: Overall perception

Once analysing statistical results gained by the model, it may be ascertained that the last model of Variant 4 with value R Square = 0.758 (Table 3), in a proper way presents empirical data. Since this model (Model 4) has high scale of correlation and small statistical error it was selected to be used.

Table 3. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error
1	.785 ^a	.616	.615	.70275
2	.856 ^b	.732	.731	.58727
3	.866 ^c	.751	.749	.56703
4	.871 ^d	.758	.756	.55922

After variables have been tested, the following model is gained:

$$LOS = 1.585 \cdot \ln \left(\frac{BrV_{15}}{L} \right) + 0.298 \cdot \ln (V(1 + \%TV)) + 5.987 \cdot SK^{-2} - 0.021 \cdot W_e^2 - 4.406 \quad (3)$$

BICYCLE LEVEL OF SERVICE SCORE

Initially, the average distribution of overall perception is tested, respectively the average of overall perception of all respondents. The lower perception was 1.48, while the highest was 5.81. Above mentioned values (1.48 and 5.81) are extreme values which might be expected in real life cases.

In this regard, the line drawn between these two extreme points, which approximately is „50 percentile”, along the line responds overall perception of 3.80. Since there are six service levels (A-F), the extreme perception which responds „50 percentile” (3.80) is selected as the point in the middle LOS-C and LOS-D (Fig.3).

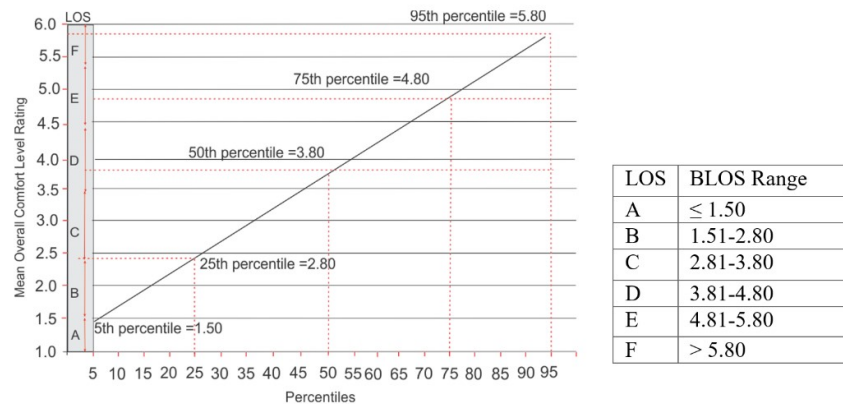


Fig.3.Bicycle Service Level score

In the following figure is shown a histogram of the residuals with a normal curve superimposed. The residuals look close to normal.

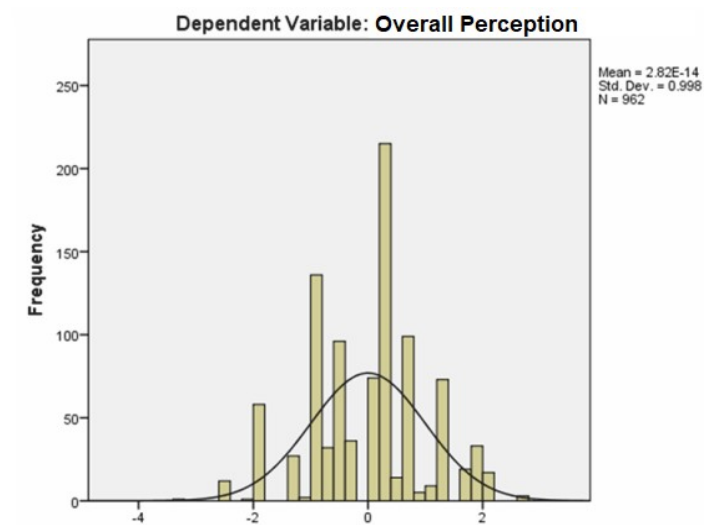


Fig.4. Histogram of the residuals

The following plot shown in Fig.5 is a check on normality, the plotted points should follow the straight line. Serious departures would suggest that normality assumption is not met. Here we have not major cause for concern.

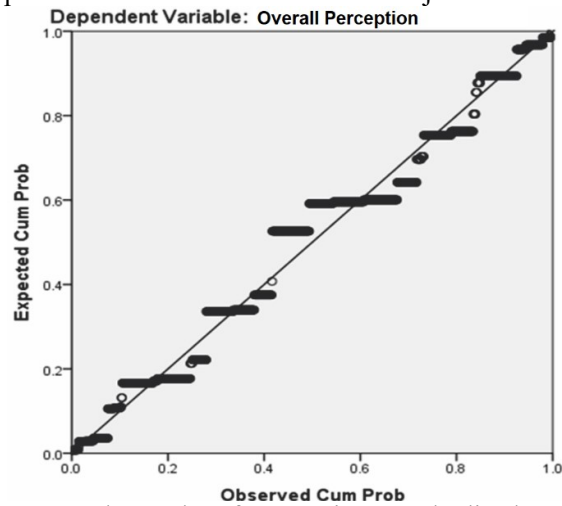


Fig.5. Normal P-P Plot of Regression Standardized Residual

MODEL APPLICATION

Results gained by the model were tested in the road network of Pristina. Based on data for thirteen roads on which the research is conducted the following results are reflected in the following Table 5.

Table 5. Bicycle Level of Service calculation

$LOS = 1.585 \cdot \ln \left(\frac{BrV_{15}}{L} \right) + 0.298 \cdot \ln (V(1 + \%TV) + 5.987 \cdot SK^{-2} - 0.021 \cdot W_e^2 - 4.406$									
Nr.	Street name	Veh ₁₅	L	V (km/h)	% HV	PC (1-5)	We (m)	Score	BL OS
1	Nazmi Gafurri	114	1	40	11	3	3.5	4.63	D
2	Haxhi Zeka	102	1	40	4.7	3	4.5	4.27	D
3	Bajram Bahtiri	70	1	40	5	4	3.5	3.55	C
4	Ilir Konushevc	157	2	40	5.8	3	3.0	4.10	C
5	Rruga Migjeni	123	2	40	2.40	3	3.5	3.63	C
6	Fehmi Agani	82	1	40	1	3	3.0	4.15	D
7	Luan Haradinaj	63	2	40	5	3	3.5	2.58	B
8	Per. Justinjan	99	1	30	0	3	3.0	4.36	D
9	Bul. B. Clinton	458	3	40	5.60	4	3.0	4.86	E
10	Lidhja e Pejes	477	2	60	18	3	3.5	6.01	F
11	Tahir Sinani	31	2	40	9.80	3	3.0	1.25	A
12	28 Nëntori	55	1	30	0	3	3	3.45	B
13	Mujë Krasniqi	32	1	40	0	3	3	2.66	B

MODEL COMPARISON

For a more detailed analysis, a comparison of the estimation model was made with the existing model in use (FDOT, 2009 [13]). For the same data of the flow to traffic and roads characteristics, calculations were made for the Bicycle Level of Service for 13 different roads in the city of Pristina. A comparison of the results are given in the diagrams shown in Fig.6.

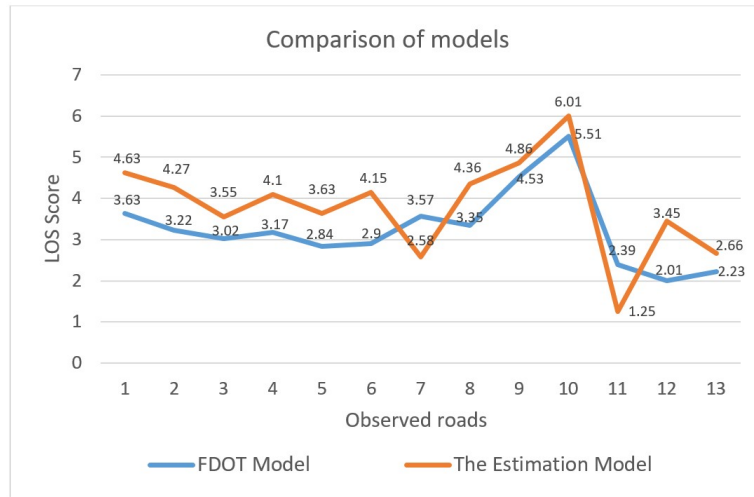


Fig.6. Comparison of models

From the figure shown above, it can be concluded that level of service ranges are lower than the ranges provided by FDOT.

CONCLUSION

The bicycle level of service categories (A-F) defined in this study can be used in general in the bicycle level of service analysis of urban streets in the city of Pristina and will help to the transportation planner and designer for a bicycle friendly environment. A bicycle map can be produced to attract bicyclist and a pollution free environment can be predicted.

The important conclusions that are drawn from the present study in defining Bicycle level of service criteria for urban streets in the city of Pristina are:

- Compared to the existing model in use (BLOS model developed by FDOT 2009 [13]), the BLOS model which is calibrated for the city of Pristina having higher coefficient values for a_1 and a_4 and lower value for a_2 and a_3 .
- From the results of the model it was found, that the numbers of motorized vehicles, vehicular speed and percentage of heavy vehicles have a negative impact and width of outside through lane, pavement condition rating have a positive impact on Bicycle Level of Service- BLOS.
- In this study it was found that, the Pristina road network does not offer good conditions for the bicycle. Also, it was found that

bicycle traveled, more often, at the poor quality of service of “D”, “E” and “F”, than good quality of service of “A”, “B” and “C”.

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