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Biking Roads Locationality Utilitarian Criteria Assessment and Measurement through Inversion Hierarchical Weight Process; Case Study: Kerman City, Iran

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ABSTRACT: The increasing growth of urbanization, urban population, and consequently an increase in traffic and the number of intercity commuters who use motor vehicles to commute has caused lots of problems for the transportation system. One of the plans by whose proper implementation traffic and urban transportation systems could be calmed down considerably is the development of human-oriented transportation (walking and biking), so, in this research, we tried to measure and analyze how suitable different routes in Kerman City are for the development of such a transportation system with its own network of passages. The current research aimed to propose a proper method to measure and study the potential and suitability of biking routes in Kerman for the kind of transportation system mentioned above. In order to analyze and rate the proposed routes within Kerman City, four international parameters were measured for each route. Based on our findings, the BCI and CBF parameters had the highest and lowest impact factors, respectively. Also, from among the ten proposed routes, Jomhouri Boulevard and Shahab Street had the highest qualitative level and Daneshgah Boulevard the lowest. According to these results, it could be concluded that the rate of trailers traffic, and the construction rate and width of passages has a considerable impact on the quality of the passages which are designed for biking.

Keywords: Biking Feasibility Study Indices, Bicycles Transportation Network, Navigating Template, Inversion Hierarchical Weight Process

INTRODUCTION

In the wake of the Industrial Revolution, the widespread use of automobiles and motor vehicles, as well as expansion or roads, pathways, and passageways, both urban and suburban, led to complicated problems in urban transportation and traffic network, particularly in large cities and city centers (Taghvaie and Fathi, 2011). After World War II, due to the drop in the price of bicycle, its imports increased, turning it into an important vehicle, so that in cities like Isfahan special tracks were constructed for bicycle traffic. With the rapid growth in the use of motor vehicles and allocation of passageways areas to their traffic, bicycle gradually lost its importance as a vehicle and its use was limited to recreational purposes. Nevertheless, in cities like Isfahan, Kashan, and Yazd, bicycle is still used as a vehicle (Hataminezhad, 2008). In Bonab and Miandoab, bicyclists play a major role in urban traffic and special crossings are allocated to them. In Isfahan, bicycles are used for 29.1% of all daily urban trips (GozarRah Consulting Engineers, 2005).

Experiences in other countries show that bicycles are used mostly by the age group of 10-50-year (Asadollahi and Saffarzadeh, 2011). Kerman, a large historical city in southeastern Iran, has a large capacity for the design, development, and equipment of bicycle crossings since it possesses the proper demographic indexes (in terms of both age group and activity type) such as age structure (80% of the population is in the 10-50 age group), historical and tourist sites scattered throughout the city, academic centers (4 public and 7 non-profit universities, 2 branches of Azad University, 12 comprehensive applied science universities, and 4 vocational and technical universities), and a large student population (Baltes, 1997). However, as yet no scientifically based study in accordance with international standards has been conducted for determining the optimum bicycle crossings in this city. This study aims to investigate the optimum bicycling routes in Kerman based on field surveys of path networks and compare them with international bicycling feasibility indexes including the codes recognized by Iran (AASHTO, 2010), the bicycling compatibility standard (BCI), the bicycling level of service standard, the Illinois Department of Transportation (IDOT) index, and the Chicago Bicycling Federation standard.

Theoretical bases of the research

Moving towards sustainable transportation is the most important solution for solving environmental problems in cities. Transportation, housing, work, and recreation, are considered the four main pillars of a city. Thus, transportation and displacement accounts for one of the most important problems in cities, so that today's urban life cannot be imagined without them. Inadequacies in urban planning and transportation have led to harmful consequences including high energy consumption, waste of time, high expenses, air pollution, audio and visual

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pollution, reduced safety, increased life-threatening hazards, and destruction of traditional urban spaces (Jahanshahloo and Amini, 2006).

A bicycle is a simple, easy to ride, and affordable device (much cheaper than other vehicles) which is considered the most efficient vehicle in terms of energy consumption (Aal Ebrahim, 2002). A bicycle can travel almost as fast as an automobile in short urban trips, and even faster during rush hour. For traveling distances under 6 km in a city, the average speed of bicycling is often more than that of other vehicles (Sheikoleslami, 1995). A bicycle needs less space for passing (0.25 m to 0.3 m), and even lesser space for parking (0.1 m), so that 15 bicycles can easily fit into the space considered for parking a car (Sheikoleslami, 1995). Moreover, the cost of ownership and maintenance (i.e., fixed and current costs) of a bicycle is minimal (Shahabian, 2003), and the costs for construction of crossings and parking lots for bicycles are far less as compared with other vehicles. It can be claimed that a bicycle does not consume nonrenewable resources (fossil fuels) and is compatible with sustainable development. Also, the energy consumed by a person for riding a bicycle a distance of 400 km is approximately equal to the energy recovered from one liter of gasoline (Aal Ebrahim, 2002). Therefore, with the energy required for producing an automobile, you can produce 100 bicycles. Bicycling promotes health and quality of life in the society (Housing and Urban Development Ministry, 1996).

Health experts are advocates of bicycling because of its useful effects on human cardiovascular system as well as on boosting people's morals. Generally, bicycles pose a lesser threat for passers-by, and, at the same time, greatly help in the reduction of air pollution and noise in urban areas. Other factors such as bicycle shape, human capabilities, regional topography, etc. are also effective on bicycle usage. These can be classified as follows: social and cultural factors, physical factors, city space structure, motorized and non-motorized transport, government policies, and personal characteristics of individuals in the society. (Kenf, 2002).

Review of literature

In his work on bicycle crossings feasibility study entitled "Bicycle Crossings Development as an Urban Transport Network", Sheikoleslami (1996) presented theoretical details on advantages of bicycling as well as various theories related to bicycling development in cities entitled "The Green Healthy Transport Paradigm" (Sheikoleslami, 1995). However, he did not offer any specific any practical guidance for location of bicycle crossings in Iranian cities. Also, in his article entitled "Views on the Development of Clean Transport Systems with emphasis on Bicycling", Honarvar (2006) pays particular attention to bicycle as a valuable device for short/recreational trips and calls it a tool for promoting health and tourism in cities. Through his comparative approach and an article entitled "A Comparative Study of Road Measurement Indexes in terms of Bicycling Possibility", Asadollahi (2010) investigated the evaluation indexes used for bicycle crossings in different codes (Asadollahi, 2010). In non-Iranian literature, Lintock in his book "Bicycle and Urban Traffic" (1992) argues that using bicycle crossings could prevent accidents and car crash (Lintock, 1992). In his book "Planning Principles for Pedestrian and Bicycle Traffic", Kenfolakhar (2008) employs statistics and mathematical calculations to design special crossings for pedestrians and bicyclists (Kenf, 2002). Baltes (1997) also conducted research on certain American cities and showed that high population densities in cities, moderate climate, and existence of large numbers of (school and university) students are the main reasons for the high share of bicycle rides in working trips.

MATERIAL AND METHODS

This study is of the applied-development type conducted in Kerman and uses the survey method. First, the bicycling codes recognized by Iran, e.g. AASHTO (the credible international code), and local standards such as "Chicago Bicycling Federation" and "Illinois Department of Transportation" were studied and used as a basis for deriving an optimum bicycling path. Upon gathering of the required theoretical, methodological, geometrical, physical, and transportation information in Kerman, the information layers were arranged in the form of a flow chart and the numerical values of the indexes were calculated. Subsequently, these indexes were ranked according to the entropy index (based on experts' opinion). Then, the reverse of each layer's rank was considered as the index's weight in the "IHWP" model. In the Delphi model, four international indexes were ranked according to their importance factors as well as experts' and scholars' opinions. With due to consideration of the related quality standard as well as path condition, these paths were rated in terms of the standard used as well as their quality and conditions by overlapping the studied layers. Thus, the input to this method consisted of the numerical values of path measurement indexes for bicycling, regional and geometrical topography, land occupancy, and demand for bicycles, and the output consisted of tables which described and rated the quality and favorability of the path based on the considered standards.

Calculation of the Selected Levels Scores

At this stage, each path was studied based on the considered indexes and subsequently placed in one of the six classes according to the total score it had obtained in the Delphi model and inversion hierarchical weight process.

$X=D/N$

X: Raw scores index

D: Score Delphi model

$J=D-(N-i)X$

N : the number of classes in each index

J : the score received for the different classes in each index

i : the numbers allocated for the various classes in each index

W: Total scores obtained on each route

The four fundamental indexes used in this study are as follows:

The Bicycle Compatibility Index (BCI)

Based on the research conducted by Sorton and Walsh (1998), the BCI index was presented by the FHWA (FHWA, 2006). This index investigates details of the path

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and not its junctions. Eight variables are used in this index for understanding the path safety. It is assumed that the bicycle considers as significant the path and the paved shoulders which are over 3 ft. The mathematical relation for this index is as follows:

$$BCI = 3.67 - 0.966(BL) - 0.410(BLW) - 0/498(CLW) + 0.002(CLV) + 0.0004(OLV) + 0.022(SPD) + 0.506(PKG) - 0.264(AREA) + AF$$

Where:

BL: a value equal to 1 if the paved shoulder or bicycle path is larger wider than 0.9 m, and equal to 0 otherwise

PKG: a value equal to 1 if the parking line acquisition is more than 30% and equal to 0 otherwise

BLW: bicycle path or paved shoulder width

CLW: width of the curb line

CLV: volume of the curb line in one direction

OLV: volume of other lines in the same direction

SPD: the 85% traffic speed

AREA: type of roadside development (residential=1, other=0)

AF=Ft+Fp+Frt: modification factor

Ft: modification factor for truck volume

Fp: modification factor for return parking

Frt: modification factor for turn right volume

Value of **AF** is the sum of the three modification factors calculated for truck volume, return parking, and turn right volume (Table 1).

Table 1. Modification Factors for Truck Volume, Round about Parking, and Turn Right Volume

Frt	Volume of Turn Right	Fp	Round about Parking *(min)*	Ft	Modification Factors for Truck Volume
0.1	<270	0.6	15>	0.5	120<
0	270<	0.5	30-16	0.4	119-60
		0.4	60-31	0.3	59-39
		0.3	120-61	0.2	39-19
		0.2	240-121	0.1	19-10
		0.1	480-241	0	10>

Table 2. Level of Service and Path Suitability based on the BCI Index

Description	Score	(i)	(D)	(x)	(j_4)
Excellent	≤1.5	(6)A			4
good	1.51 - 2.3	(5)B			3.334
Fair	2.31 - 3.4	(4)C	(4)	(0.66)	2.668
Poor	3.41 – 4.4	(3)D			2.002
Deficient	4.41 - 5.3	(2)E			1.336
Unsafe	> 5.3	(1)F			0.666

As can be observed in Table 2, six different values are determined for this index in proportion with service levels A to F, ranging from extremely high to extremely low.

Bicycle Level of Service (BLOS)

Landis et al. (1997) used this method by replacing the rider's reaction in a virtual environment with an actual path. The bicycle level of service is very similar to BCI with in terms of sensitivity to the curbside traffic line width. In this method, traffic volume dependency increases logarithmically with low and medium traffic levels (AASHTO, 2010). The mathematical model for this index is as follows:

$$BLOS = 0.507 \times \ln (Vol15/Ln) + 0.199 \times SPt (1+10.38HV) 2 + 7.066 \times (1/PR5)2 - 0.005 \times (We) 2 + 0.76$$

Where:

Vol15: directional traffic volume in 15 minutes equal to:

(ADT . D . Kd)/(4 . PHF)

ADT: average daily traffic

D: directional factor

Kd: daily factor peak

PHF: Peak hour factor (1.0 assumed)

Ln: number of straight directional lines

SPt: Effective Speed Limit (1.1199 . Ln (SPp – 20) + 0.8103)

SPp: posted speed limit

HV: Percentage of heavy vehicles

PR5: Pavement condition rating based on FHWA's 5-point scale

We: Average effective width of outside through lane

Table 3. Appropriate Level of Service and Path Suitability based on the BLOS Index

Description	Score	(i)	(D)	(x)	(j_3)
Excellent	≤1.5	(6)A			3
good	1.51 - 2.5	(5)B			2.5
Fair	2.5 – 3.5	(4)C	(3)	(0.5)	2
Poor	3.5 – 4.5	(3)D			1.5
Deficient	4.5 - 5.5	(2)E			15
Unsafe	> 5.5	(1)F			0.5

IDOT Bicycle Map Index:

In this method, the four criteria, i.e., type of paving, line width, paved shoulder, and average daily traffic, are divided into three areas. Table 4 presents the values for each criterion. (IDOT, 1995)

Table 4. Proposed Values in the IDOT Index

Criteria	Description	Value
Surface Quality	High Quality	0.54
	Low Quality	0.019
	Dirt and oil	0.006
Path width	>12	0.189
	10-11.9	0.052
	<10	0.019
Path width of pavement	>4	0.132
	3-1	0.033
	none	0.012
Average daily traffic	750>	0.374
	750-2000	0.082
	>2000	0.028

The values obtained from Table 4 are summed up and the results presented as Table 5.

Table 5. Path Suitability Measurement via the IDOT Index

More than 2,000 cars and 200 trucks		Less than 2,000 cars and 200 trucks		Average daily traffic	
>0.300	≤0.300	>0.5	0.3-0.5	≤0.300	**IDOT Value**
Yellow / Medium (2)	Red / bad (3)	Green / Good (3)	Yellow / Medium (2)	Red / bad (1)	**Ratin**
	(2)			(D)	
	(0.666)			(x)	
1.333	0.666	3	1.333	0.666	(j_2)

The CBF Bicycle Map Index: (CBF, 2000)

In this method, only the traffic volume parameters, traffic speed, and curbside line width (as well as the paved shoulder and bicycle path width) are used. The presented index depends on traffic speed and bicycle path width and paved shoulder width, and is possibly strongly dependent on the curb side line width as well (CBF, 2000).

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Table 6. Path Suitability according to the CBF Index corresponding to bicycle path width/paved shoulder width (in *yards*)

Up to 5000		**1250-5000**			**500-1250**			**Under the 500**		**ADT/Lane**
12-13-14		12-13-14			12-13-14			12-13-14		Width Speed
Yellow	Red	Green		Yellow	Green			Green		<35 Mph
Red	--	Yellow		Red	Green		Yellow	Green		35-45Mph
Red	--	Yellow	Red	--	Green	Yellow	Red	Green	Yellow	45-50Mph
--		Red	--		Green	Yellow	Red	Green	Yellow	>50Mph

Table 7. Measurement of Path Suitability according to the CBF Index

	(CBF)			
Non-recommended	**Red**	**Yellow**	**Green**	**CBF Value**
	(1)			(D)
	(0.25)			(x)
0.25	0.5	0.75	1	(j 1)

It was seen that through comparative investigation of these indexes, their relative characteristics can be determined. We observed that the BLOS method is mostly affected by heavy vehicles traffic volume. This method is very similar to the BCI method, but the BCI method is also affected by line width and marginal parking conditions. In the IDOT method, only traffic parameters as well as line width and paving conditions are effective, whereas in the CBF method, both speed and traffic volume plays a role (Saffarzadeh and Asadollahi, 2010). The purpose of all these indexes is to measure path suitability for bicycling. However, each index measures this based on different parameters with different coefficients/factors. Therefore, each index must be used with due consideration to the required goal and the selected parameter. Otherwise, the more exact and comprehensive measurement method under similar conditions would be to consider all these indexes. To this end, the index output values must be unified into a common range for comparison and evaluation. In this way, the studied bicycling paths are evaluated based on each index and a final score is obtained by calculating the mean scores and grades.

Recognition and analysis of the studied region

Kerman is a developing city with a population in excess of 534,441 residing in an area of circa 15814.5224 hectares. The traffic produced by the 148,000 passenger cars in this city often results in heavy congestion throughout the city due to the physical conditions of passageways and the way they are used. A good reason for construction of bicycle crossings along historical paths in this city is its high tourist attraction potential. In 2011, 7814 foreign and 96142 domestic tourists visited Kerman. Moreover, due to the hot and dry climate and relatively smooth topography of the city, bicycle and pedestrian paths with favorable conditions can be constructed through moderate investment.

Experiences in other countries show that bicycling trips are mostly done by people in the age groups of 10 to 50 years (Saffarzadeh and Asadollahi, 2011). Those under 10 years of age usually make recreational trips including travel to and from school and educational centers. Statistics produced by Iran Center for Statistics show that about 80% of the population in Kerman belong to this age group, providing a high investment potential for the city in this regard. Meanwhile, as was mentioned in the Introduction, Kerman is also an academic city, so that its students can optimally (in terms of both age and activity type) use bicycles (Baltes, 1997). For this reason, Kerman meets the requirements set for this case study.

Determination of the Bicycling Paths

Determining whether a city has a favorable potential for bicycling trips would require a thorough investigation of all its thoroughfares and arterial roads. Upon completion of such investigation, a continuous uniform path can be proposed in accordance with the relevant standards. However, due to the existing conditions and the limited initial analysis conducted in this regard, we considered only some of the paths in Kerman (considering all the paths would be outside the scope of this study). The initial conditions for establishing bicycling paths were considered for the studied paths. An effort was made to select the paths based on the following criteria: minimum number of required trips, minimum physical terms and conditions, suitable path length (4 *km*), origin and destination use, and use of partition walls required for building bicycle crossings. All the proposed paths are relatively favorable with regard to the above criteria.

Layout of the Proposed Paths on the Map

As shown in Figure 1, the proposed path network connects nearly all commercial and recreational centers of the city in an east-west direction. Moreover, the central city routes which extend to the south (where most academic centers are situated) can be used by bicyclists as well. Obviously, institutionalizing the bicycle as an official transport vehicle in the city would require an inter-connected loop path network. However, the 9 proposed paths in the present study would suffice since the purpose here was to determine path suitability.

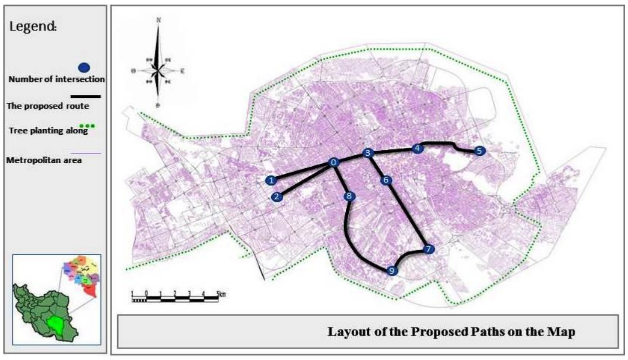

Figure 1. Layout of the Proposed Paths on the Map

Investigation of Sections based on the BCI Index: Table 9 presents the collective results obtained from the BCI formula and Table 2. For each path in this table, a level of service was determined and a numerical score proposed according to the inverse hierarchical analysis. According to these results, the highest scores were obtained for Jomhouri Islami Blvd. and Shahab Street. Low levels of truck traffic, suitable width of the side line, low overall traffic volume, and existence of suitable parking lots along these paths contribute to these high scores.

Table 9. Path Scores based on the BCI

(j_4)	Suitability	level of Service	BCI Value	Street Name
3.334	Good	B	1.81	Jomhouri
2.668	Fair	C	2.9	Sadoughi
2.002	Poor	D	4.3	Shariati(E)
2.002	Poor	D	4	Khajou
2.668	Fair	C	3.15	Zarisof
2.002	Poor	D	4	Garani
2.002	Poor	D	4.2	Shariati(w)
3.334	Good	B	2.2	Shahab
2.668	Fair	C	3.1	Resala
1.336	Deficient	E	4.9	Daneshgah

Investigation of Sections based on the BLOS Index: According to the calculated results from the BLOS formula and the scores in Table 3, the highest scores for level of service were obtained for Jomhouri Blvd Sadouhgi Blvd., and Shahab Street. These results as well as the numerical score obtained from the inverse hierarchical analysis are presented in Table 10. A reason why Sadoughi Blvd. has a higher suitability based on the BLOS index (as compared with the BCI) is that the BCI is more dependent on paving conditions and path width.

Table 10. Path Scores based on the BLOS Index

(j_3)	Suitability	level of Service	BLOS Value	Street Name
2.5	Good	B	1.7	Jomhouri
2.5	Good	B	2.4	Sadoughi
1.5	Poor	D	4	Shariati(E)
1.5	Poor	D	4.1	Khajou
2	Fair	C	3.5	Zarisof
1.5	Poor	D	4.4	Garani
1.5	Poor	D	3.8	Shariati(w)
2.5	Good	B	2.4	Shahab
2	Fair	C	3.4	Resala
2	Fair	C	3.45	Daneshgah

Investigation of Sections based on the IDOT Index: Results obtained from Table 4 and scores shown in Table 5 indicate that the highest scores for this index went to Jomhouri Blvd., Sadoughi Blvd., Shahab St., and Resala St.. These results are presented in Table 11. The high sensitivity of this particular index to the number of passing trucks placed the Daneshgah Blvd. (which has a high level of truck traffic) at the bottom of the table due to its poor score.

Investigation of Sections based on the CBF Index: The scores and levels of service obtained for the paths and arterial roads based on the information in Table 6 and Table 7 are presented in Table 12. These results are somewhat different from those obtained from other methods due to the sensitivity of this method to path width and speed of vehicles passing in the line next to the bicycling line. As can be seen, Jomhouri Blvd. and the Sadoughi Blvd. which earned very good scores in the other methods have earned lower ranks in this method due to their higher speed limits. Instead, Khajou and Zarisof streets scored higher because vehicle moved at lower speeds along these streets.

Table 11. Path Scores based on the IDOT Index

(j_2)	Suitability	level of Service	IDOT Value	Street Name
3	Good	Green	0.749	Jomhouri
3	Fair	Green	0.403	Sadoughi
1.334	Fair	Yellow	0.323	Shariati(E)
1.334	Fair	Yellow	0.323	Khajou
1.334	Fair	Yellow	0.323	Zarisof
1.334	Fair	Yellow	0.323	Garani
1.334	Fair	Yellow	0.323	Shariati(w)
3	Good	Green	0.749	Shahab
3	Good	Green	0.749	Resala
0.666	Unsafe	Red	0.266	Daneshgah

Table 12. Path Scores based on the CBF Index

(j_1)	Suitability	level of Service	CBF Value	Street Name
0.75	Fair	Yellow	-	Jomhouri
0.75	Fair	Yellow	-	Sadoughi
0.75	Fair	Yellow	-	Shariati(E)
1	Good	Green	-	Khajou
1	Good	Green	-	Zarisof
0.75	Fair	Yellow	-	Garani
0.75	Fair	Yellow	-	Shariati(w)
0.75	Fair	Yellow	-	Shahab
0.5	Deficient	Red	-	Resala
0.25	Unsafe	--	-	Daneshgah

RESULTS AND DISCUSSION

Superposition and Sum of the Numerical Scores for each Path

The final suitability score for each path was calculated from the sum of the scores obtained from the Delphi model and the inverse hierarchical analysis. The partial effects of various scores in the final result were calculated through the weight assigned to each by the Delphi model.

Table 13. Individual and Final Path Scores

$W=\sum_{k=1}^{4} j\ k$	CBF	IDOT	BLOS	BCI	Street Name
9.584	0.75	3	2.5	3.334	Jomhouri
8.918	0.75	3	2.5	2.668	Sadoughi
5.586	0.75	1.334	1.5	2.002	Shariati(E)
5.836	1	1.334	1.5	2.002	Khajou
7.002	1	1.334	2	2.668	Zarisof
5.586	0.75	1.334	1.5	2.002	Garani
5.586	0.75	1.334	1.5	2.002	Shariati(w)
9.584	0.75	3	2.5	3.334	Shahab
8.168	0.5	3	2	2.668	Resala
4.252	0.25	0.666	2	1.336	Daneshgah

At this stage, the score spectra were calculated by assuming extreme paths with superior and very inferior quality. This method was used to specify the least and the most favorability for the paths, and ultimately provide the most suitable quality grading for them.

Table 14. Score Spectra and Path Quality Values

	Score Spectra	Description
Score Spectra and Path Quality Values	9.51-11	Excellent bicycle environment
	8.1-9.5	Good bicycle environment
	6.51-8	Fair bicycle environment (acceptable to experienced and novice bicyclists)
	5.1-6.5	Poor environment (acceptable to experienced bicyclists)
	3.51-5	Deficient environment (Unacceptable to experienced and novice bicyclists)
	2-3.5	Unsafe environment (Unsuitable for any bicycle travel)

Table 15 shows the final favorability and the general resultant obtained for each path from Table 13 and comparison with Table 14.

Table 15. Path Quality based on Path Scores

Description	Score	Street Name
Excellent bicycle environment	9.584	Jomhouri
Good bicycle environment	8.918	Sadoughi
Poor environment (acceptable to experienced bicyclists)	5.586	Shariati(E)
Poor environment (acceptable to experienced bicyclists)	5.836	Khajou
Fair bicycle environment (acceptable to experienced and novice bicyclists)	7.002	Zarisof
Poor environment (acceptable to experienced bicyclists)	5.586	Garani
Poor environment (acceptable to experienced bicyclists)	5.586	Shariati(w)
Excellent bicycle environment	9.584	Shahab
Good bicycle environment	8.168	Resala
Deficient environment (Unacceptable to experienced and novice bicyclists)	4.252	Daneshgah

Final Demonstration of Path Quality and Favorability Results on the Map

The final results show that Shahab Street and Jomhouri Islami Blvd. earned the highest score, highest quality, and highest favorability. On the other extreme, the Daneshgah Blvd. ranked the lowest in terms of quality and favorability. For better demonstration, the results of Table 15 are shown in Figure 2.in the form of a color spectrum.

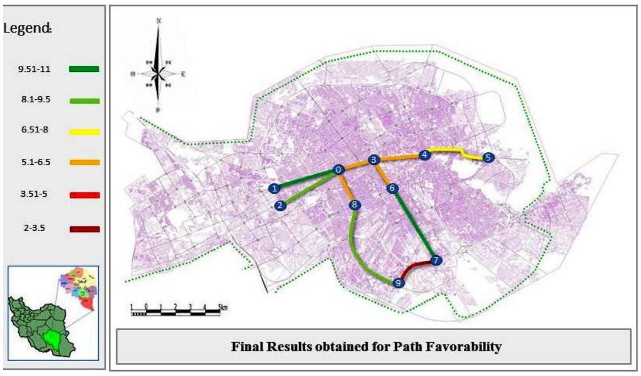

Figure 2. Final Results obtained for Path Favorability

Analyzing the results

As can be observed in the above results and the presented map, if certain paths, e.g., 3-0, 4-3, 6-3, and 8-0, are reinforced, a continuous bicycling network can be implemented in Kerman. The major shortfalls in these paths are due to the volume of traffic and their narrow widths. However, allocation of special bicycling lanes or reinforcement of public transport system (for reducing traffic volume and lowering the allowable speed limit) can increase the favorability of these paths. Also, due to the great gap between the conditions of the 7-9 paths and the favorable range, no investment for this path may be avoided. The favorability scores obtained for the 7-9 paths are low due to its high traffic volume and high design speed. For this path, construction of a separate bicycle path on the pavement might be considered as an option.

CONCLUSION

In this article, the BCI, BLOS, IDOT, and CBF indexes were calculated for certain paths of a bicycling network and the obtained overlapped results for these indexes were subsequently presented and used in decision making. Each index emphasizes on specific aspects, so the different results were obtained for certain paths. For measuring the effects of different factors on path favorability, we must consider all these indexes collectively for obtaining reliable results.

As observed in the article, the main emphasis for favorability in all these indexes was path width, allowable design speed, and sometimes paving quality and truck traffic volume. However, factors like conditions of junctions along the path or local features like road use or origin and destination use can also play a role in path favorability, none of which has been considered in the above indexes. It is therefore suggested that the Intersection Evaluation Index (IEI) and Road Safety Index (RSI) which have indeed considered these additional factors be used in more comprehensive studies in this field (AASHTO, 2006).

Meanwhile, in the Side Path Suitability Measure(SPSM) index, factors such as traffic, intersection, path continuity, curb section, simultaneous use by bicyclists and pedestrians, and other parameters are considered (Barostti, 2001), which make this a suitable index for exact professional designing.

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