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Infrastructure Factors Influencing Urban Cycling in a Cultural Heritage City[*]

ปัจจัยโครงสร้างพื้นฐานที่มีอิทธิพลต่อการใช้จักรยานในเมืองมรดกทางวัฒนธรรม

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Abstract

The purpose of this study is to analyze the cultural heritage city infrastructure factors of cycling in the urban areas which is based on a case study in Chiang Mai, Thailand. The data was collected by a Likert questionnaire from four hundred of the road users by using the Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA) and Structural Equation Model (SEM). According to the analysis results, there are 4 latent variances of the EFA which are a Bicycle Lane (BL), a Bicycle Entrepreneur (BE), a Bicycle Network (BN) and a Bicycle Parking (BP). As in the CFA analysis, it found that all of the latent variances has validity or consistent with the empirical data as shown in the CFA, and the SEM analysis also has validity or consistent with the empirical data as well (χ^2 = 91.427, df = 79, *p* value = .160, GFI = .977, IFI =.997, CFI = .997, RMSEA = .020). Additionally, a Bicycle Lane (BL) factor has been directly influenced both in a Bicycle Network (BN) factor and a Bicycle Entrepreneur (BE) factor while a Bicycle Entrepreneur (BE) factor has been directly influencing a Bicycle Network (BN) factor and a Bicycle Parking (BP) factor.

[*] To analyze the cultural heritage city infrastructure factors of cycling in the urban areas which is based on a case study in Chiang Mai, Thailand.

เพื่อวิเคราะห์ปัจจัยด้านระบบโครงสร้างพื้นฐานของเมืองมรดกทางวัฒนธรรมที่มีอิทธิพลต่อการใช้จักรยานในเขตเมือง โดยศึกษากรณีเมืองเชียงใหม่ ประเทศไทย

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Keywords: Cultural Heritage City, Infrastructure Factors, Cycling, Urban

บทคัดย่อ

การศึกษานี้มีจุดประสงค์เพื่อวิเคราะห์ปัจจัยด้านระบบโครงสร้างพื้นฐานของเมืองมรดกทางวัฒนธรรมที่มีอิทธิพลต่อการใช้จักรยานในเขตเมือง โดยศึกษากรณีเมืองเชียงใหม่ ประเทศไทย ข้อมูลสำหรับการวิเคราะห์ได้จากแบบสอบถามแบบประมาณค่า (Likert) จากผู้ใช้รถใช้ถนนจำนวน 400 คน เก็บข้อมูลโดยใช้วิธีสุ่มอย่างง่าย ข้อมูลใช้การวิเคราะห์องค์ประกอบเชิงสำรวจ (Exploratory Factor Analysis : EFA) การวิเคราะห์องค์ประกอบเชิงยืนยัน (Confirmatory Factor Analysis : CFA) และการวิเคราะห์โมเดลสมการโครงการ (Structural Equation Model: SEM) ผลการวิเคราะห์ข้อมูลพบว่า องค์ประกอบเชิงสำรวจ (EFA) แบ่งได้ 4 ปัจจัยแฝง (Latent variances) ได้แก่ ลักษณะกายภาพของทางจักรยาน (Bicycle Lane: BL) ผู้ประกอบการจักรยาน (Bicycle Entrepreneur: BE) โครงข่ายทางจักรยาน (Bicycle network: BN) และสถานที่จอดจักรยาน (Bicycle Parking: BP) เมื่อวิเคราะห์องค์ประกอบเชิงยืนยัน (CFA) พบว่า ทุกปัจจัยแฝงของโมเดลสมการโครงสร้างมีความตรงเชิงโครงสร้างหรือมีความสอดคล้องกับข้อมูลเชิงประจักษ์ ส่วนผลการวิเคราะห์โมเดลสมการโครงสร้าง (SEM) พบว่า โมเดลมีความตรงเชิงโครงสร้างหรือมีความสอดคล้องกับข้อมูลเชิงประจักษ์ (χ^2 = 91.427, df = 79, *p*-value = .160, GFI = .977, IFI =.997, CFI = .997, RMSEA = .020) โดยปัจจัยแฝงลักษณะกายภาพของทางจักรยาน (BL) มีอิทธิพลโดยตรงกับปัจจัยแฝง โครงข่ายทางจักรยาน (BN) และปัจจัยแฝง ผู้ประกอบการจักรยาน (BE) ขณะที่ปัจจัยแฝง ผู้ประกอบการจักรยาน (BE) มีอิทธิพลโดยตรงกับ โครงข่ายทางจักรยาน (BN) และปัจจัยแฝง สถานที่จอดจักรยาน (BP)

คำสำคัญ : เมืองมรดกทางวัฒนธรรม, ระบบโครงสร้างพื้นฐาน, การใช้จักรยาน, เมือง

Introduction

Chiang Mai, where is a capital of the ancient “Lanna Kingdom” (A Kingdom of a million of rice fields), was purposefully created by King Mangrai in AD.1296 to be the political, economic, social and cultural center of his newly expanded and integrated kingdom of the Tai people. Nowadays Chiang Mai is a cultural heritage city of Thailand and one of a tentative list of the World Heritage sites. There are many interesting properties in Chiang Mai for instance 1) the cultural landscape of the old city: Wat Pra That Doi Suthep, Chet Lin (7 streams), Mae Ping river, 2) the historically significant monuments, sites, and landscapes where is located both in the inner and outer fortification of the city: 4 sides of a city walls, 4 sides of the moats, 5 city gates and 4 city corners 3) the significant monuments and sites within the city walls: Wat Chedi Luang, Wat Chiang Man, Wat Sai Mun Muang, Kum Bureerat (Palace), Wiang Kum Kam (Archaeological site) 4) the modern significant monuments and sites: the first Christian church, the first school building, the first hospital building, the first Chinese community temple, the first Muslim community and mosque. In addition, there are several art and cultural, wisdom knowledge, festivals and traditions in Chiang Mai which is held annually at the significant monuments, sites, and landscapes of the Chiang Mai city (Thailand National Committee for World Heritage, 2015).

Chiang Mai is a city that has been developed into a major regional hub since the National Economic and Social Development Plan No. 4 (1982-1986) which is led to the city's development in various fields for instance the utilities infrastructure, institutions, hospitals, hotels, banks, department stores, establishments and private companies. (National Economic and Social Development Board Office of the Prime Minister, 1981). Not only Chiang Mai could access more easily by cars, trains or airplanes but it also modernizes the city with several amenities. The comfortable living is becoming more popular for both Thais and foreigners as the number of tourists is increasing every year. Recently, there are more than 7 million tourists in Chiang Mai which has been making more than 58,000 million baht income in 2013. (Chiang Mai Province Official, 2015) (As shown in Table 1).

Table 1 Visitors and revenues of Chiang Mai between the years 2003-2013

TOURISM IN CHIANG MAI				
Years	Visitor	Visitor Thai	Visitor Foreign	Revenue (Million Baht)
2003	3,399,906	1,062,892	1,308,812	38,290.92
2004	3,898,543	1,328,168	1,613,145	45,066.89
2005	3,997,776	1,360,520	1,623,653	31,120.43
2006	5,590,326	1,688,308	1,719,558	39,785.06
2007	5,356,867	1,659,495	1,414,911	38,894.25
2008	5,313,352	1,646,006	1,348,183	38,135.33
2010	5,040,917	1,785,163	1,293,842	43,070.23
2011	5,661,673	2,004,999	1,848,584	39,507.03
2012	6,570,642	4,378,320	2,192,322	58,550.50
2013	7,089,792	4,747,887	2,341,905	58,863.72
Total	51,919,794	21,661,758	16,704,915	431,284.36

Source: Chiang Mai Province Official, 2015

According to the increasing number of tourists as mentioned above, it cause several effects which is happening with the others touristic cities from all over the world especially in the vehicles' impacts. It causes air pollution, traffic jams, transportation issues and noise pollution (Davenport & Davenport, 2006; Komain Kantawateera et al., 2015; Moharamnejad et al., 2012 ; Saenz-de-Miera & Rosselló, 2014 and Thongphon Promsaka Na Sakolnakorn et al., 2013). However, the Chiang Mai Municipality endeavors to solve these problems by campaigning for cycling more. At least, it could be another way to reduce those impacts (Nordback, 2014; Ogilvie, 2011; Pucher & Dijkstra, 2003; Reynolds, 2009 and Zuurbier et al., 2010) by developing revising and organizing the routes around the city and also the cycling infrastructure for examples lanes markings, bicycle signs, traffic signs, contra flow, bicycle lanes, bicycle boulevard (Saenz-de-Miera & Rosselló, 2014). (As shown in Figure 1-4).

Figure 1 Lanes marking for bicycle

Figure 2 Bicycle signs and traffic signs

Figure 3 Contra flow bicycle lanes

Figure 4 Bicycle boulevard

A good and suitable infrastructure is very important for cycling to ensure the safety of lives and property of the cyclists (Dill, 2009; Federal Highway Administration, 1999; Harris, 2013; Reynolds, 2009 and Teschke, 2012). In accordance with the attitude of those who use the road towards the cycling infrastructure in Chiang Mai urban areas, it interestingly found that the propriety is only in a moderate level (mean =2.90). Therefore, the cycling infrastructure in Chiang Mai urban areas' analysis is really important to encourage using more bicycles. It would help alleviating the problems of Chiang Mai where is a cultural heritage city of Thailand onwards.

Theories and Literature Reviews

The concept of bicycle path consists of a bicycle path pattern, bicycle path development, bicycle infrastructure (AASHTO, 1999), planning and design for cycling in urban environments (Tolley, 2003) and bicycle parking (APBP, 2002; USDOT, 2007). Related literature found that the factors that affect the bicycle use were bike lanes, bike paths, secure bicycle parking and time (Hunt & Abraham, 2007), suitable bicycle infrastructure and safety (Chataway et al., 2014; Fishman et. al., 2012; Marques et. al., 2015; Pucher et al., 2010), bicycling policies (Noland & Kunreuther, 1995; Rietveld & Daniel, 2004; Suminski et. al., 2014; Wardman et al., 2007) and travelling behaviors, traveler characteristics, cycling promotion plans and legislation related to the bicycle usage (Usanee Raha & Viroat Srisurapanon, 2011).

Methods

Data Collection

This study were collected the data from 400 road users in Chiang Mai (100 pedestrians, 100 cyclists, 100 motorcyclists and 100 drivers) by simple random sampling in Chiang Mai old city area and on eight routes with dense traffic (red dotted line, as shown in figure 5) and using a questionnaire. Table 2 displays the sample characteristics The result shows that about 38.8% of the road users were in Chiang Mai suburban and 30% in Chiang Mai Urban, most of the road users were student and private employees.

Table 2 Description of sample (n = 400)

Variable	Level	Frequency	Percent
Gender	Male	205	51.2
	Female	195	48.8
Educational level	College or equivalence	192	47.9
	Bachelor's Degree or equivalence	183	45.8
	Master's Degree or equivalence	25	6.3
Occupation	Private employees	133	33.3
	Government / State Enterprise	48	12.0
	Private Company	82	20.4
	Student	137	34.3
Domicile	Chiang Mai Urban	152	38.0
	Chiang Mai suburban	155	38.8
	Other provinces	93	23.2

This questionnaire is consisting of 19 items about the infrastructure factors of a cultural heritage city that related to the cycling in urban areas, which is assessed on five-point Likert scale (1 = strongly disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree) (Likert, 1932) and a scale reliability was checked by computing the Cronbach's alpha (.913). The descriptions of 19 variables were showed in Table 3.

Figure 5 Chiang Mai old city area and eight routes with dense traffic

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Table 3 Variable descriptions

Variable	Description	Level & Agreement
BikeSign	Bicycle Signs	1 = strongly disagree
Obstruction	Obstruction in Bicycle Lanes	2 = Somewhat Disagree
Ramp	Ramp for Bicycle Lanes and Sidewalk	3 = Neither Agree nor Disagree
Environment	Environment of Bicycle Lanes	4 = Somewhat Agree
Parking	Number of Bicycle Parking Places	5 = Strongly Agree
Capacity	Bicycle Parking Capacity	
Security	Bicycle Parking Security	
Entrepreneur	Bicycle Entrepreneurs	
Rental	Number of Rental Bicycle	
Usability	Usability of Rental Bicycle	
Marking	Lanes Markings	
Position	Current position Labels	
Barrier	Bicycle Lanes Barrier	
TrafSign	Traffic Signs	
Route	Bicycle Routes	
Contraflow	Contra Flow Bicycle Lanes	
Boulevard	Bicycle Boulevard	
NumRoute	Number of Bicycle Routes	
Map	Bicycle Routes Map	

Data Analysis

The analysis is consisting of three procedures. There are 19 items were initially checked the appropriate components by the exploratory factor analysis (EFA). The factor extraction has been using a principal component analysis and the Varimax rotation method, and a descriptive statistic has been calculating by using SPSS program. Subsequently, each of the components was checked by a confirmatory factor analysis (CFA) by using AMOS program. Lastly, the Structural Equation Model (SEM) was carried out by using AMOS program; the statistic is including Chi-square (χ^2), the Goodness of Fit Index (GFI), the Incremental Fit Index (IFI), the Comparative Fit Index (CFI) and the Root Mean Square Error off Approximation (RMSEA). For the Chi-square measures, p value ≥.05, was suggested as a criteria of the acceptable model fit, value ≥.90 for the Goodness of Fit Index (GFI), the Adjusted Goodness of

Fit Index (IFI), the Comparative Fit Index (CFI), and value ≤.05 for the Root Mean Square Error off Approximation (RMSEA).

Results and Discussion

The analysis has shown that the exploratory factors consisting of 4 components: (As shown in Table 4). The first component is consisting of 8 variables; Marking, Position, Traffic Signs, Barrier, Bike Signs, Ramps, Environment and Obstruction which is contributed a latent variable as a Bicycle Lane (BL). The second component is consisting of 3 variables; Usability, Rental and Entrepreneur which is contributed a latent variable as a Bicycle Entrepreneur (BE). The third component is consisting of 5 variables: Routes, Control flow, Boulevard, Number of Routes and Map which is contributed a latent variable as a Bicycle Network (BN). The fourth component is consisting of 4 variables: Capacity, Parking and Security which is contributed a latent variable as a Bicycle Parking (BP). The latent constructs were illustrated in Figure 6.

Table 4 Rotated Component Matrix

	Component			
	1	2	3	4
Marking	**.785**	.300	-.057	.082
Position	**.765**	.357	.009	.057
TrafSign	**.725**	.413	-.071	.148
Barrier	**.705**	.385	-.206	.286
BikeSign	**.686**	.089	.358	.176
Ramp	**.642**	.130	.402	.115
Environment	**.639**	.073	.382	.051
Obstruction	**.622**	-.044	.496	-.054
NumRoute	.123	**.729**	.022	.334
Map	.358	**.722**	.283	-.083
Contraflow	.110	**.692**	.511	.052
Route	.402	**.658**	.260	.033
Boulevard	.420	**.628**	.273	.039
Rental	.105	.206	**.836**	.086
Usability	.039	.245	**.792**	.084
Entrepreneur	.165	.191	**.658**	.411
Security	.065	.064	.161	**.865**

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Parking	.145	.049	.026	**.852**
Capacity	.106	.093	.131	**.849**

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization

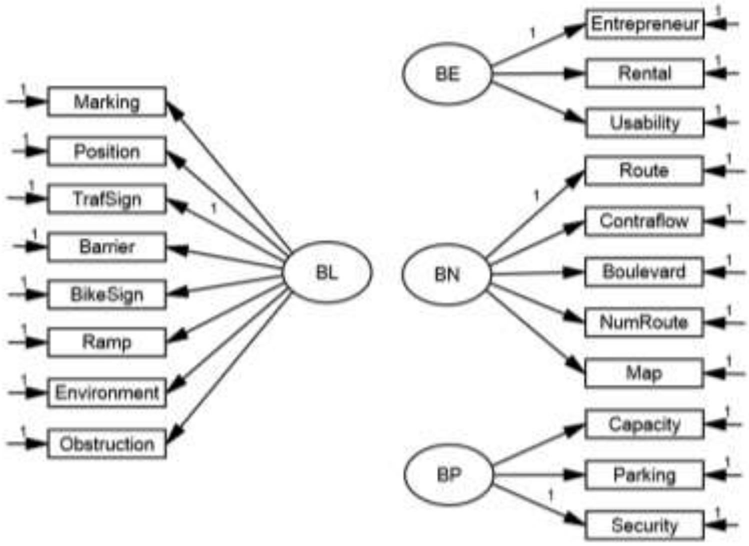


Figure 6 Latent constructs for infrastructure factors

The results of the confirmatory factor analysis has showed that all of four analysis (Bicycle lane factor: BL, bicycle entrepreneur factor: BE, bicycle network factor: BN and bicycle parking factor: BP) fit well with the empirical (As shown in Table 5) and it has been standardized a regression weight of factors and variances which is shown in Table 6.

Table 5 Results of the Confirmatory Factors Analysis

	χ^2	df	*p*	GFI	IFI	CFI	RMSEA
Value			≥.05	≥.90	≥.90	≥.90	≤.05
BL	11.009	9	.275	.993	.999	.999	.024
BE	0.555	1	.456	.999	.993	1.000	.000
BN	3.938	3	.268	.996	.981	.999	.028
BP	1.560	2	.458	.998	.988	1.000	.000

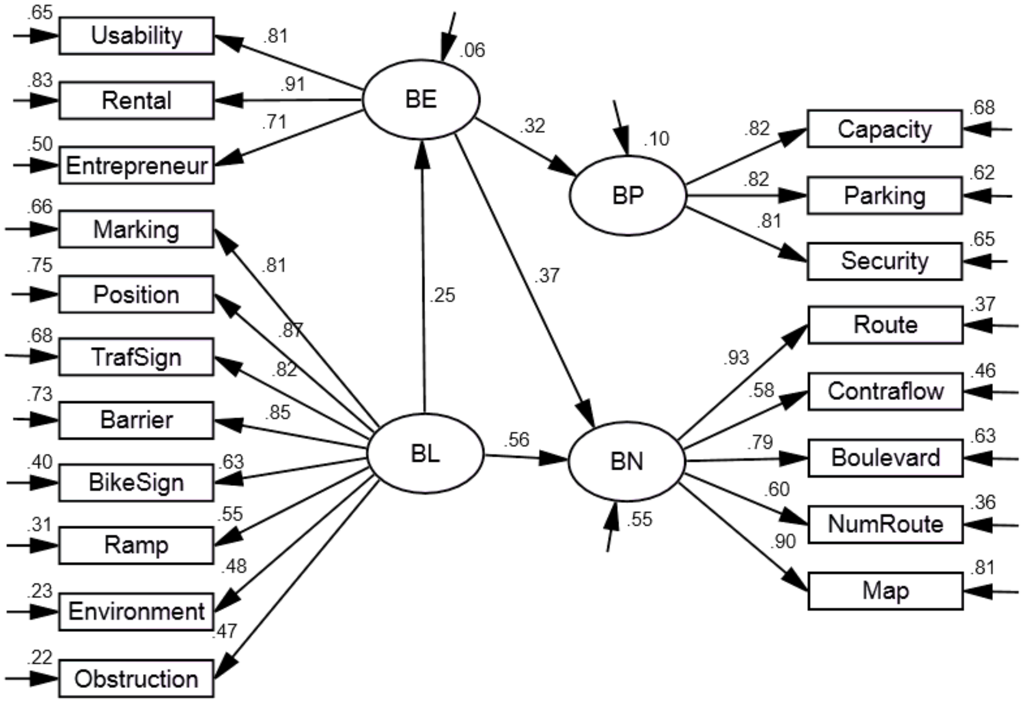
Table 6 Standardized Regression Weight

			Estimate
BE	<---	BL	.255
BN	<---	BL	.558
BP	<---	BE	.320
BN	<---	BE	.365
Barrier	<---	BL	.853
Position	<---	BL	.866
Route	<---	BN	.925
Contraflow	<---	BN	.581
Boulevard	<---	BN	.793
NumRoute	<---	BN	.598
Map	<---	BN	.902
Parking	<---	BP	.819
Capacity	<---	BP	.825
Entrepreneur	<---	BE	.710
Rental	<---	BE	.911
Usability	<---	BE	.805
Security	<---	BP	.809
Environment	<---	BL	.482
Ramp	<---	BL	.553
Obstruction	<---	BL	.474
Marking	<---	BL	.813
BikeSign	<---	BL	.629
TrafSign	<---	BL	.824

The results of the structural equation model analysis (SEM) showed that the model was fit well with empirical (χ^2= 91.427, df = 79, *p* value = .160, GFI = .977, IFI =.997, CFI = .997, RMSEA = .020). The relationship of the components are as the following: bicycle lane component (BL) has directly influenced the bicycle network component (BN) and bicycle entrepreneur component (BE), while bicycle entrepreneur component (BE) has been directly influencing bicycle network component (BN) and bicycle parking component (BP) (As shown in Figure 7).

As a result of the relationship analysis above, there is one interesting component which is a bicycle lane component (BL). It has influenced a bicycle entrepreneur component (BE) by considering the variables of the bicycle lane component (BL). It seems that most of the variables were engaging by the government for instance lanes markings, current position labels, traffic signs, bicycle signs, ramps for bicycle lanes and sidewalks and bicycle lanes barrier. If examining the variables of bicycle entrepreneur component (BE), there will be the operating from the private sectors through the variables such as the usability of rental bicycles, a number of rental bicycles and bicycles' entrepreneurs. According to the relationship above, it is shown that the government variables (BL) were influenced by the private sectors' variables (BE). It has been reflecting on the cultural heritage city infrastructure operation relating to the cycling in urban areas which is still mainly requiring the assistance from the government especially the relevant state sectors such as a local government, the provincial administration organization and the provincial office undertaking the main role of the operations.

However, the result of this analysis has found that both of the government variables (BL) and the private sectors' variables (BE) have been influenced a bicycle network factor (BN) which is operating on bicycle routes, contra flow bicycle lanes, a bicycle boulevard, a number of bicycle routes and a bicycle routes map. According to this relationship, it has shown that the cultural heritage city infrastructure operation relating to the cycling in urban still require the cooperation between the government and private sectors because they are relevant and coherent. The public sector is the backbone of the power and mechanisms of the bureaucratic and the related sectors (Civil works, urban traffic plan and tourism enforcement) as the implementation of the strategic and policy, the budget allocation and so on while several private sectors are supporting and encouraging by to be the funding source and practical support, to cooperate and to educated those who use the road.



χ^2= 91.427, df = 79, *p* value = .160, GFI = .977, IFI =.997, CFI = .997, RMSEA = .020

Figure 7 Structural Equation Model

Conclusions and Recommendation

The objective of this study is to analyze the city's cultural heritage infrastructure factors of cycling in the urban areas which is based on the case study in Chiang Mai, a capital of the ancient Lanna kingdom. The data were collected by the Likert questionnaire from four hundred road users: pedestrians, cyclists, motorcyclists and drivers, the analysis using the Exploratory Factor Analysis (EFA), the Confirmatory Factor Analysis (CFA) and the Structural Equation Model (SEM). As the results, the Exploratory Factors Analysis (EFA) is consisting of four components which are a Bicycle Lane (BL), a Bicycle Entrepreneur (BE), a Bicycle Network (BN) and a Bicycle Parking (BP). The Confirmatory Factor Analysis (CFA) has showed that all of four analysis fit well with the empirical and the Structural Equation Model(SEM) analysis has shown that the model was also fit well with the empirical (χ^2=91.427, df = 79, *p* value = .160, GFI = .977, IFI =.997, CFI = .997, RMSEA = .020).

In accordance with the relationship among the various factors, it found that a bicycle lane factor (BL) which is a public sectors' variables influencing a bicycle entrepreneur factor (BE) which is a private sectors' variables. Therefore all of the government agencies should be taken hastily by urgently determining the policy and planning the strategic, implementation strategies and budget allocation to alleviate all of the existing problems. This will be the ways to reduce the impacts which might be occurred in the future. This study found that both of the bicycle lane factor (BL), which is a public sectors' variables and bicycle entrepreneur factor (BE) which is a private sectors' variables have been influenced a bicycle network factor (BN). Thus, both relevant public and private sectors should jointly organize, study and encourage the cultural heritage city infrastructure operation relating to the cycling in urban areas properly for example the developed concepts, the developed direction determination, the operation boundaries, the practical responders and the supporting budgetary to be able to operate and determine the cultural heritage city infrastructure operation relating to the cycling in urban areas effectively.

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