Bicycling Network Development for Tourism and Travel in Wiang Phayao, Thailand

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Abstract
This study aims to analyse and present the Bicycling Network Development for Tourism and Traveling in Wiang Phayao, Thailand. A study was conducted to reveal the potential of road transportation network to develop a supporting network for bicycle mode for tourism by analyzing the provincial transportation plan, transit map and popular route for travelers in Wiang Phayao. The researcher also studied criteria of bicycle route design by using the Multi Criteria Analysis: MCA which provided 2 optional bicycle networks. From the analysis of optional bicycle network for tourism and traveling using digital spatial analysis technique called "Space Syntax" found the most suitable option to finalise the bicycle route. This option rendered better results because of the high tendency of travelling and for travelers who are not local people for easy understanding the characteristic of routes more than other option.

1. Introduction

Wiang Phayao is located in the area of Muang Phayao, Thailand, with a large community where is mixture land use is of mixed nature such as *residence, business, government office and public utilities (school, park, market, shop and restaurant).* They are all located nearby so travelling around Wiang Phayao is very convenient. Additionally, Phayao is also well known as a historical area and many attractive places around Kwan Phayao. They are important places for tourist to stop by. Wiang Phayao is a small community, the majority of the area is flat and all attractive places are located nearby, using a bicycle is a flexible and effective way to explore the community due to the short distances between landmarks which are approximately 0.5-7.5 kilometers away from each place (Nelson and Scholar, 2009 and Heinen, 2011). Bicycles are also a useful option to travel in daily life, for exercise and tourism. Nowadays, bicycles are becoming popular in Wiang Phayao, people are gathering as a group to cycle every evening after work, even on weekends and public holidays to visit important attractive places. However, people use the same bicycle route over and over every day and the route has not been developed for tourism. Thus, this Bicycling Network Development for Tourism in Wiang Phayao will encourage and increase the bicycling network in order to reduce energy for transportation, reduce the travel expenses, decrease the traffic congestion in rush hours, support health promotion, and activate the bicycling network to support tourism in Phayao Province (Campbell and Wittgens, 2004).

2. Methods

The methodology is summarized in the flowchart shown in Figure 1.

2.1 Data Acquisition and Preparation

2.1.1 Fundamental transportation network data was collected from related departments and by field survey. These are *1) Physical characteristics of route, 2) Average daily traffic, 3) Accident record, 4) Tourist attractive places / Landmarks, and 5) Land use.*

2.1.2 Preferential routes of cyclist data and comparation of important levels among criteria standards of bicycle route design by using questionnaire, the sample group was 90 people who travel around Wiang Phayao. They were separated in 3 groups according to their activities of travelling, 1) Occupation– 30 samplings (government officer, worker, employee, and services), 2) Tourism– 30

samplings (Tourists and cyclist), and 3) Residence – 30 samplings (Residents of Wiang Phayao)

2.2 Data Analysis

2.2.1 Potential Analysis in developing the bicycle route for tourism and travel were from 7 standard criteria for bicycle route design:

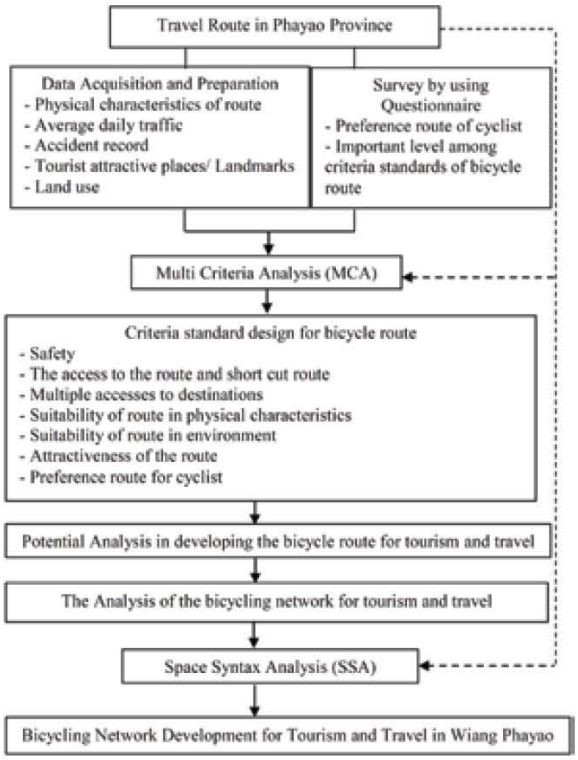

Figure 1: Flowchart of methodology

1) Safety, 2) The access to the route and short cut route, 3) Multiple access to destinations, 4) Suitability of route in physical characteristics, 5) Suitability of route in environment, 6) Attractiveness of the route, and 7) Preference route for cyclist (Hudson, 1984, Wongchum, 2005, ASSHTO, 2012 and DOH, 2015) by using Multi Criteria Analysis: MCA (Saaty, 1980, Malczewski, 1999 and Hsu and Lin, 2011) to compare the importance of standard criteria in bicycle route design by creating the matrix table to compare each pair of criteria regarding the data collection from the 90 samplings of travelers in Wiang Phayao, then presented in picture of Weighting Factors under the following criteria of comparison are:

1) If the vertical criterion is more important than the horizontal criterion, the number of comparison point is 3. 2) If the vertical criterion and the horizontal criterion are equal, the number of comparison point is 2. 3) If the vertical criterion is less important than the horizontal criterion, the number of comparison point is 1. 4) If the vertical criterion and the horizontal criterion are the same, the number of comparison point is 0. After comparing the data pairwise, then summarize all important total points of each criterion to compare ratio by weighting sum of each criterion is 1.0. The most important criterion will have the highest point. (Shown in Table 1).

The nineteen roads in Wiang Phayao are connecting the all recreation areas, tourist attractive places, downtown, education areas and residence areas and it is convenient for travelling as informed by the people. This information was considered by adding points regarding the suitability of criteria standard for bicycle route design. Suitability index points of the bicycle route helped development of tourism and travel connectivity. The most suitable road will be allocated 3 points, and the unsuitable road will add 0 points (Shown in Table 2). After getting weighting factors and suitability scores for each road, the potential development score were calculated by using the below description (Rybarczyk and Wu, 2010):

$$S = W_1X_1 + W_2X_2 + \ldots\ldots + W_nX_n$$

Equation 1

Where,

S = Total potential development score

$W_1, W_2, \ldots, W_n$ = Weighting factors of each criterion

$X_1, X_2, \ldots, X_n$ = Suitable scores of each criterion

Total potential development score for each road in transportation network was classified to identify level of potential development using equal interval which is divided into 3 levels, 1) High potential (2.01-3.00), 2) Moderate potential (1.01-2.00), and 3) Low potential (0.00-1.00). Results were classified and presented into the map.

2.2.2 The Analysis of the bicycling network for tourism and travel which is suitable/ convenient in the area in Wiang Phayao by considering information of the Optional Bicycling Network from criteria standard of bicycle route design with transportation type by bicycle and demand of local people.

Table 1: Example of weighting factor numbers of criteria standard in bicycle route design

Criteria standard in bicycle route design	W_1	W_2	W_3	W_4	W_5	W_6	W_7
Safety (W_1)	0	1	2	1	1	2	1
The access to the route and short cut route (W_2)	3	0	2	n2	2	2	2
Multiple accesses to destinations (W_3)	2	2	0	2	1	2	1
Suitability of route in physical characteristics (W_4)	3	2	2	0	2	3	2
Suitability of route in environment (W_5)	3	2	3	2	0	3	2
Attractiveness of the route (W_6)	2	2	2	1	1	0	1
Preference route for cyclist (W_7)	3	2	3	2	2	3	0
Total	**16**	**11**	**14**	**10**	**9**	**15**	**9**
Weighting Factor	**0.19**	**0.13**	**0.17**	**0.12**	**0.11**	**0.18**	**0.11**

Table 2: Scoring the potential to develop the bicycle route for tourism and travel

Criteria standard designs for bicycle route		**Score**	**Source**
1) Safety (S1)	The average daily traffic		Checking Point for The daily traffic
	1) Less than 500 cars/day	3	
	2) 501-1,000 cars/day	2	
	3) 1,001-1500 cars/day	1	
	4) More than 1,500 cars/day	0	
	Accident Record		Phayao Provincial Police Station 2012
	1) No accident	3	
	2) 1-5 times/year	2	
	3) 5-10 times/year	1	
	4) More than 10 times/year	0	
2) The access to the route and short cut route (S2)	1) Easy to access the route and short cut route	3	Field Survey
	2) Difficult to access the route and roundabout way	0	
3) Multiple accesses to destinations (S3)	1) Access to land use more than 3 types	3	Field Survey
	2) Access to land use 2 types	2	
	3) Access to land use 1 type	1	
	4) not across to the waste land	0	
4) Suitability of route in physical characteristics (S4)	1) One-way road with same width of road and two ways road with wider road	3	Field Survey
	2) Two ways road with narrow road	0	
5) Suitable for environment (S5)	1) Shady road, crowded buildings and enough light along the road	3	Field Survey
	2) Shady road, crowded buildings and not enough light along the road	0	
6) Attractiveness of the route (S6)	1) Eye appealing point	3	Field Survey
	2) No eye appealing point	0	
7) Preference for cyclist (S7)	1) 31-50 time/day	3	Questionnaire
	2) 11-30 time/day	2	
	3) 1-10 time/day	1	
	4) No cyclist	0	

Then compared the Optional Bicycling Network for tourism and travel by using the Space Syntax Analysis (SSA) (Hillier et al., 1993, Hillier, 1996, Pinelo and Turner, 2010 and Liu et al., 2016) by statistical analysis as the following;

1) The Embedding Analysis of travel network, the optional network that has a good value. Embedding Analysis means that the network has a trend to be more popular in using and traveling due to the high potential to access to compare all networks in town. There are two ways to analyze the values of Embedding Analysis, which are Global Integration Value and Local Integration Value.

2) The Connectivity Value Analysis is to find the value which shows the connection of the route in network system, by showing the number of routes that are connected with the route in the system.

3) The Synergy Value Analysis which is the index of relation between the Global Integration Value and Local Integration Value. If one of the routes has high Synergy Value that means the integration of that network is great. The route will be preferred to use and travel for multiple purposes both Global integration Value and Local Integration Value.

4) The Intelligibility Value Analysis which is the index of relation between the Connectivity Value and the Integration Value. If travelling network is consisted of the route that has a high Synergy Value to understand, this means that people who travel around in the area has trend to understand the overview of all the routes from traveling in the small route. It means people who understand the road network will not get lost.

These statistics analysis will be presented in a colored chart, the high value of a route is in red, and the low value of route is in blue.

3. Results

3.1 The Analysis of the Potential to Develop the Bicycle Route for Tourism and Travelling.

The result of comparison for standard criteria in designing bicycle route from 90 persons of sample group who are travelling in Wiang Phayao has shown the important pattern of weight values in each criterion (Table 3) found the sampling of traveler in Wiang Phayao give the priority to safety first than they consider the physical characteristic of the route. It meant that the bicycle routes must avoid the overlapping of the routes that are having overcrowded vehicles. In the meantime, it can be connected to effective network which is convenient for travelling; roads must be wide enough, slope must be suitable that should not be an obstacle for riding bicycle and road surface should be smooth. If it is considered in each activity groups, it showed that every group give a high priority to the 1st and the 2nd criteria; safety and the suitability of physical characteristic for route. There are a few differences in 3rd criteria which will be considered in a group of work activity and tourism to focus on accessing the route and short cut route that should be accessed easily, quickly and must be a straight route without any intersection. Nevertheless, the group of residence activity gives priority to the access to multi destinations. Their requirements are the bicycle route should be designed to cover full area encompassing various activities, especially the area that is important in economic, social and physical characteristic for Wiang Phayao.

Table 4 and Figure 2, show the result for the consideration of the suitability scores of each road by using the criteria for standard designs for bicycle route and the average of weight value from evaluation of the sample groups who travel in Wiang Phayao. The road that has the highest total score is the route that has the highest potential to develop the bicycle route for tourism and travel. And the road that has the lowest total score is the route that has the lowest potential to develop the bicycle route for tourism and travel, or it is the route that doesn't need to be developed for a bicycle route, for example, the route that had high accident records, or the route that people rarely use. The routes that have the high scores will be chosen to develop the bicycle routes. Due to the limited budget, not every route will be developed Priority will be given to just only some essential routes which are necessary for bicycle riding. It will be chosen to be optional bicycle network in various patterns which has different potential for development.

3.2 The Analysis of the Bicycling Network for Tourism and Travelling that is Suitable and Related to the Area of Wiang Phayao.

3.2.1 The recommendation of optional routes which is suitable for development

The analysis of Bicycling Network for Tourism and Travelling in Wiang Phayao was designed into two options (Figure 3), each option was analyzed based on information of the area, provincial transportation plan, travel types, and route preference which were

considered together with suitability criteria to develop the good option for bicycle route. Later, the analysis of the advantages and limitations was conducted to choose which each option has better ideas of using the route.The first option idea of network focuses on the straight route, travelling on this route will be fast and safe. This also has the access to the areas involving various uses. On the other hand, the second option idea focuses on the route on the minor and main road, not the main roads to access to residence area with safety, and reach to tourist attractive places, interesting places, and land of various uses.

Table 3: Weighting factor numbers of criteria standard designs for bicycle route

Criteria standard designs for bicycle route	Weighted Mean			
	Working Activity	Travel Activity	Resting Activity	People who travel in Wiang Phayao
Safety (S1)	0.19	0.19	0.20	0.20
The access to the route and short cut route (S2)	0.17	0.15	0.14	0.15
Multiple accesses to destinations (S3)	0.13	0.13	0.17	0.14
Suitability of route in physical characteristics (S4)	0.18	0.15	0.15	0.16
Suitable for environment (S5)	0.10	0.12	0.12	0.11
Attractiveness of the route (S6)	0.09	0.12	0.11	0.11
Preference for cyclist (S7)	0.14	0.13	0.10	0.13
Total	**1.00**	**1.00**	**1.00**	**1.00**

Table 4: Potential to develop the bicycle route for tourism and travel

Road Names	Criteria standard of bicycle route design									Bicycle Facilities
	S1	S2	S3	S4	S5	S6	S7	Suitability scores	Potential Level	
Ngam Mueang	2	3	3	0	3	3	3	2.38	High	Bike Lane
Phahon Yothin	2	3	0	3	3	3	1	2.21	High	Bike Lane
Chai Kwan	1	3	3	0	3	3	3	2.18	High	Bike Path, Bike Lane
Rop Wiang Pratu Pu Yi	3	3	3	2	3	0	1	2.16	High	Bike Route
Tha Kwan	1	3	0	2	3	3	2	2.03	High	Bike Lane
Don Sanam	0	3	0	3	3	3	2	1.95	Moderate	Bike Lane
Phahon Yothin Sai Kao	2	3	0	0	3	3	1	1.88	Moderate	Bike Route
HuaKhuang Kaeo	3	3	0	2	3	0	1	1.82	Moderate	Bike Route
Rop Wiang Pratuchai	3	2	3	0	3	0	1	1.79	Moderate	Bike Route
Rop Wiang Pratu Klong	0	3	0	3	3	0	3	1.59	Moderate	Bike Route
Pratuchai	0	3	0	0	3	3	1	1.49	Moderate	Bike Route
Ruam Mit	3	1	0	0	3	0	1	1.31	Moderate	Bike Route
Santi Rat	2	3	0	0	3	0	1	1.30	Moderate	Bike Route
Ratcha Khruet	2	2	0	0	3	0	1	1.26	Moderate	Bike Route
Ratchawong	3	2	0	2	0	0	2	1.25	Moderate	Bike Route
Thet Samphan	2	3	0	0	0	0	2	1.07	Moderate	Bike Route
Prasat	3	2	0	0	0	0	2	1.03	Moderate	Bike Route
Rat Samphan	3	1	0	0	0	0	2	0.88	Low	Bike Route
Prathet Udon Thit	2	1	0	0	0	0	2	0.79	Low	Bike Route

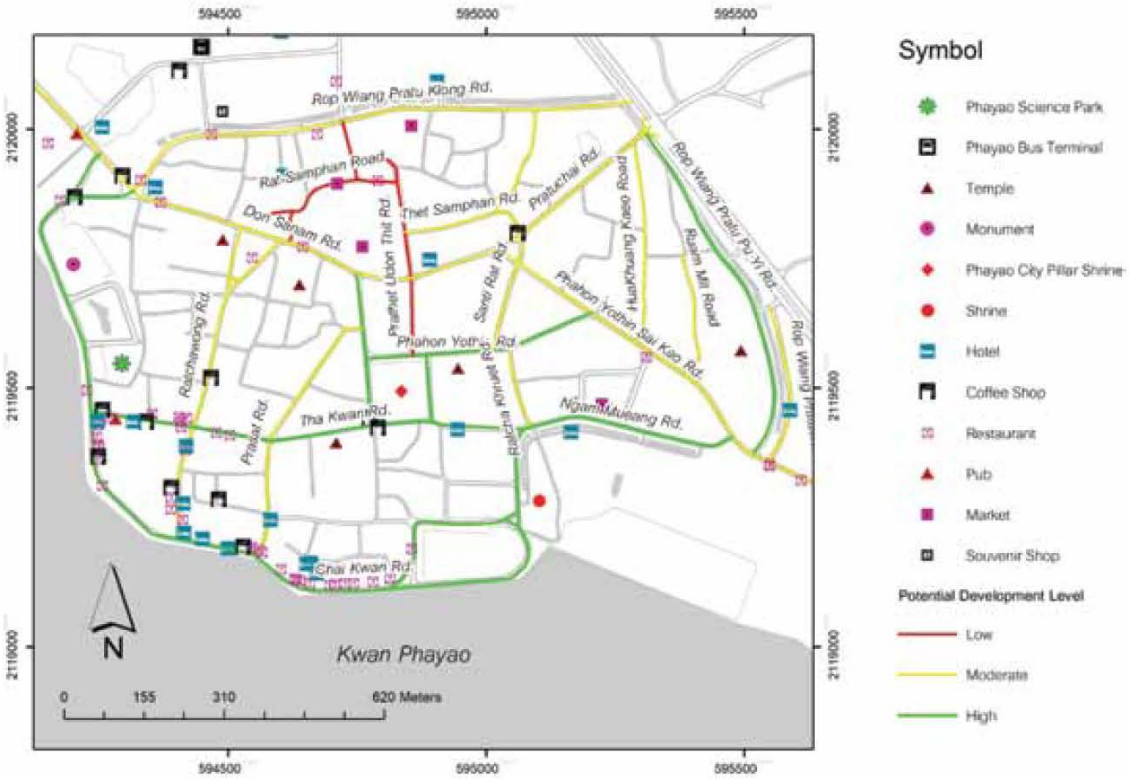

Figure 2: Potential to develop the bicycle route for tourism and travel

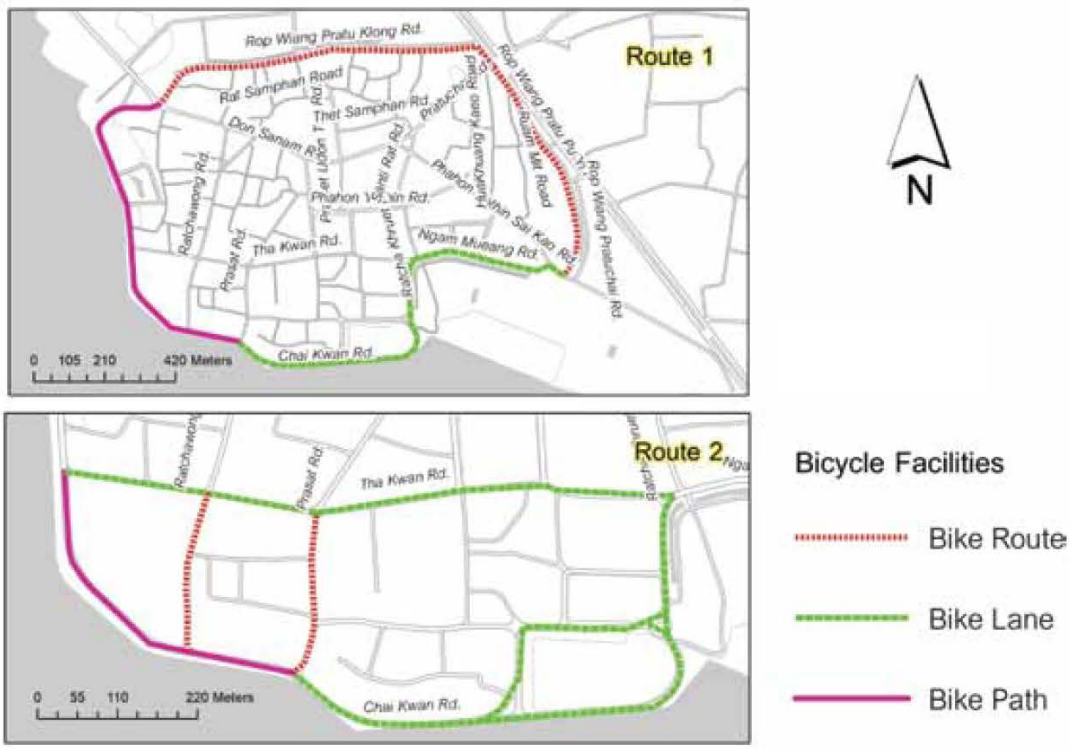

Figure 3: Optional Bicycling Network

Each route has details as the followings;

1) The First Optional Bicycling Network, the bicycle route must be across the main road and minor road, which is a straight route or a route that people prefer to travel. Travelling on this route should be fast and go through the land in various utilization, wide road, pass tourist attractive places, pass tourist facilities e.g. accommodation, sight attraction points, interesting places, including shelters must be provided along the road to support people who travel through this route in the future. The network of this route consists of Chai Kwan Road, Ngam Mueang Road, Rop Wiang Pratu Pu Yi Road, and Rop Wiang Pratu Klong Road, the total distance is 4.1 kilometers, cycle time is about 15-30 minutes. The Chai Kwan Road and Ngam Mueang Road are preference roads for people and tourists to cycle and appreciate the beautiful panoramic view where is surrounded by green nature is along the south east moat and Kwan Phayao including the important places, there restaurants and coffee shops located along the road. According to this road that is a wide-two lane road, it is proposed to create the bike lane on this road. Some part of Chai Kwan road has public area where the footpaths are available for people to walk in the park, it can be developed to the bike path that can be shared to be walk way as well. Rop Wiang Pratu Pu Yi Road is along the east moat, which cuts through an important architectural area of Wiang Phayao, it is a shady road and light traffic, therefore the bike route is proposed to be shared on the normal road. Because of convenient construction, low budget and matching with travelling type of local people.

The Rob Wiang Pratu Klong Road is roads which go through architecture area of Wiang Phayao. It is along the north moat and connected to Phayao Arcade Market, and Phayao bus station. Along this road, there are crowded commercial places and sufficient light at night time. However this road is quite narrow and it is a two lane road, the road cannot be extended wider because it is blocked by buildings along the sides. Thus the suggestion is not to separate the bike lane but should be a joint road (bike route). Regarding traffic congestion, there should be traffic management to avoid accidents and maintain safety on the road, for example, one-way road arrangement, no parking; some types of cars are prohibited to drive through in the rush hours. These enforce preventive measures to be appropriately applied to traffic management.

2) The Second Optional Bicycling Network, which is consisted of Chai Kwan Road, Tha Kwan Road, Ratchawong Road, and Prasat Road. The total distance is 3 kilometers, cycle time is around 10-20 minutes. This route has access to accommodations, shops, restaurants, tourist attraction places in Wiang Phayao and outstanding tourist activities such as walking street market, and paddle with lighted candles in hands around a temple in the middle of the lake. Chai Kwan Road and Tha Kwan Road are wide - two lane roads, so these roads can be created a bike lane join on the normal road and can be created bike path in some areas of Chai Kwan Road. They are for safety purpose of inexperienced cyclists, and for supporting the increased people who travel through this route in the future. In contrast, Ratchawong Road and Prasat Road are narrow roads, with access to the residential areas and it has light traffic. The recommendation is to create the joint lane for a bike route and normal road because this is convenient for construction, low budget and matched with travelling type of local people.

3.2.2 Comparison Analysis on the optional bicycle network for tourism and travelling by Space Syntax technique.

Embedding Analysis of transportation network in Waing Phayao (Figure 4), found that Global Integration Value is high and it is a highest potential route that people are going through. These are Phahon Yothin Road, Prathet Udon Thit Road, and Don Sanam Road where are located in the centre of Wiang Phayai. On the other hand, Local Integration Value is very high. It is the potential route for people to travel to the centre of Wiang Phayao, which are Pratuchai Road, Don Sanam Road, Prathet Udon Thit Road, and Phahon Yothin Road. After considering the connectivity, it revealed that the high potential of road connectivity was related to the road that had high Local Integration value. Therefore, from the trend of travelling in Waing Phayao, people travel through local roads more than the central roads. After analysis of the road network of Wiang Phayao by considering the Intelligibility Value and Synergy Value (Figure 5) it showed that the Intelligibility Value of Wiang Phayao was low, R^2 = 0.2973, which meant the road network of Wiang Phayao is complex and confused and travellers who are not familiar to the roads have a higher chance to get lost.

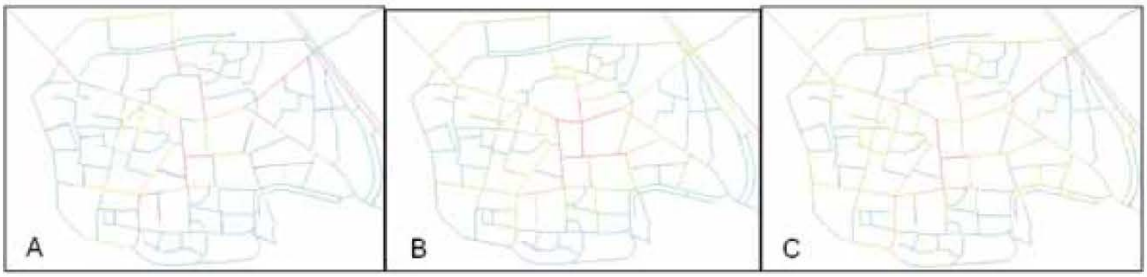

Figure 4: Connectivity (A) Global Integration (B) and Local Integration (C)

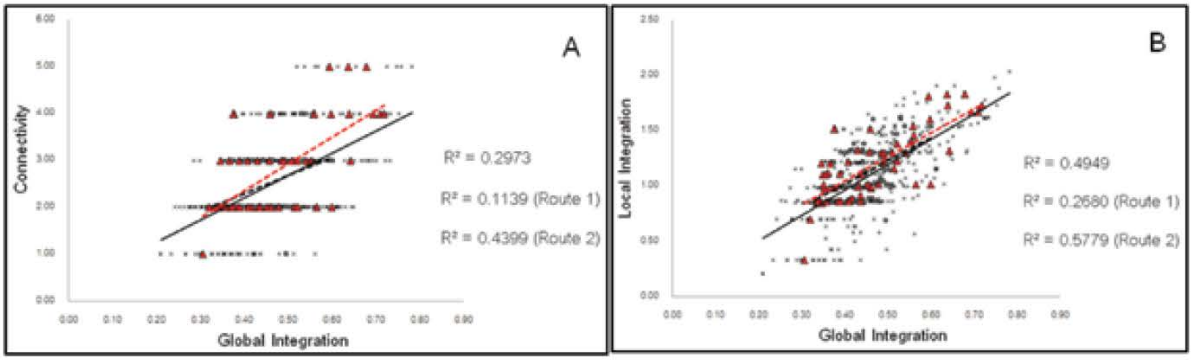

Figure 5: Intelligibility Value (A) and Synergy Value (B)

Figure 6: Bicycle Network in Wiang Phayao

Due to the numerous minor roads, and some of them are not connected to the main road. Therefore, Synergy Value was not bad, $R^2 = 0.4949$, it revealed that people prefer to travel through both local roads and central roads. According to the consideration of both values, the understanding of transportation network system of Wiang Phayao is for the travellers who are not local people will have difficulty to travel and find directions, however, the local people will be able to travel conveniently on both local roads and centre roads. After consideration to compare Embedding Value of transportation network between the first and the second optional bicycle network by considering the Synergy Value and Intelligibility Value (Figure 4), it presented that the second option of bicycle network had higher Embedding Value than first network (Synergy Value of the first optional network was 0.2680 and Synergy Value of the second optional network was 0.5779).

This means that the second optional network has a higher chance for travelling both local roads and main roads. Furthermore, travellers trend to have more understanding in the second optional network than the first optional network (The Intelligibility Value of the first optional network was 0.1139, and the second optional network was 0.4399). Thus, the second optional network is more

suitable to develop and plan for the bicycle route in Wiang Phayao.

4. Discussion and Conclusions

The road network in Wiang Phayao has both local and center roads for the people to travel around regularly. The roads are diverse, convenient and connected to the city. However, some routes still need to be rebuilt to connect with main roads and reduce the confusion of directions by developing the route in unique ways and easy to remember and understand (Hillier and Hanson, 1984 and Paksukcharern, 2005). In the Spatial Analysis, the potential of transportation network was to develop the road for the bicycle route for tourism and travelling in Wiang Phayao. Refer to the analysis of Provincial Transportation Plan, Types of travelling, preference route of people to travel in Wiang Phayao, criteria for standard design for bicycle route, including multi criteria analysis: MCA were used to find optional routes and finally to develop the final bicycle route.

The first option, the bicycle route will be built involving the main roads and minor roads. Normally these are straight routes or choice route that people prefer to travel. Travelling on this route should be convenient and fast; this also included from across the various land use and the wider roads.

There should be facilities provided along the travel route, e.g. accommodation, sight attractions, interesting places, including shelters along the road to support the increasing of people who travel through this route in the future. The second option, the bicycle route must be connected between main road and residence or minor road that is high safety to tourist attractive places, interesting places and important activities points and the wide route, sight attractions and shelters along the road including should have capacity to increase more bicycle routes in the future. Both optional bicycle networks have advantages and limitations which each route having different ideas for using the route.

Then a Comparison Analysis on the optional bicycle network for tourism and travelling using Space Syntax to find Synergy Value and Intelligibility Value. The results showed that the route 2 had higher Synergy Value than route 1. There the route 2 is found to be suitable to develop and construct the bicycle route in Wiang Phayao. From the result of analysis found Space Syntax Computer Program has the potential for both optional networks in term of embedding, accessing and understanding of routes by statistical system. Both cases of optional networks have similar advantages and limitations, it supports to have higher confidence levels for planning (Hillier, 1996).

Using bicycle is one of the methods of transportation system that can be used to travel for doing numerous activities, such as going for work, exercise, and tourism. Moreover, it can help to save energy and environment, reduces pollutions from driving, as well as decreases the effects of traffic congestion (Campbell and Wittgens, 2004). The management of bicycle route by Muang Phayao Municipality is conformed to the second optional bicycle network and found that those bicycle routes are used in moderate level. However, the bicycle facilities and recourses are still needed. Moreover, people who travel by cars disagreed with the concept to build the bicycle route because they need space to park their cars along the side of the road. Thus, in order to be a sustainable development in the future, the bicycle network route in Wiang Phayao, should have a continued campaign to encourage people to travel by bicycle, and bicycle facilities should be adequately provided, for example, parking for bicycles, bathrooms along the road to change cloths, safety aspects, car parking area and pick up service, no entry or parking permission time (ASSHTO, 2012 and DHO, 2015). Those preventive measures should be applied as appropriate according to the traffic management in Wiang Phayao. It would support to encourage people's attitude to increase their travelling by bicycle in the future.

Acknowledgements

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