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THE STUDY OF VULNERABLE ROAD USER FACILITIES IN MAGELANG CITY TOWARDS SUSTAINABLE TRANSPORT SYSTEM

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ABSTRACT

The existing development of the city is often oriented on the motorized transportation. Congestion and air pollution bring negative effects due to the increasing population and decreasing quality of transport services. The sustainable transport system is expected to be a solution to improve the quality of transportation services.

This paper provides an overview and analysis of the current condition of vulnerable road user (VRU) facilities in Magelang city, analysis of public expectations and identification of strategies that might be taken to develop VRU facilities related to the concept of sustainable transport system. This research includes the study and performance analysis of pedicabs, bicycles and pedestrian facilities in Jalan Pahlawan and Jalan Ahmad Yani Magelang compared to the Indonesia's road geometric standard.

The primary and secondary data were analyzed with descriptive statistics in the form of tables, graphs, charts, and Importance-Performance Analysis (IPA). Jalan Pahlawan met the criteria and has VRU facilities while VRUs traffic on Jalan Ahmad Yani didn't meet the criteria for the provision of the slow lane. Based on the analysis of trip generation and attraction, variables that affect the number of trips are the number of family members, the bicycle ownership, motorcycle ownership and car ownership. The motorcycle ownership is the highest. The VRUs are threatened by growing motorization.

Facilities for VRUs are already available and meet the indicators, but has not yet been realized for all of the roads in Magelang city. IPA analysis included in quadrant 3 and 4, which means low priority and respondents were fairly satisfied with the existing facilities.

The ignorance of nonmotorized transport may increase air pollution, energy use, traffic congestion, traffic safety problems, urban sprawl, and global climate change. The improvement of park and ride facilities, public transport and traffic calming for VRUs needs to be done to integrate VRUs and motorized transport.

Keywords: Sustainable transport system; vulnerable road user facilities.

1. INTRODUCTION

The development of transportation has affected many aspects of life, including economic, energy and environmental aspects. The population density has a strong effect on the ability of transport to meet the travel needs of society. Based on the data on *Kota Magelang Dalam Angka* (Magelang in number) 2013, Magelang has population growth

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of 0.44% with the revenue increase of 14.69%. This condition was compounded with the development orientation of urban space in the motorized mode of transportation systems, ease of ownership of private vehicles and inadequate quality of public transport caused a declining quality of transport services, such as the occurrence of congestion, air pollution and exhaust gas emissions accretion. The quality of transport services is later analyzed in five dimensions, namely tangibles, reliability, responsiveness, assurance, and empathy (Zethamal, Parasuraman, Berry (1990) in Setyawan 2012).

Policy patterns in our country are focused on highways, induce continued increase of private vehicle ownership without improvement and upgrade of variable road user (VRU) infrastructure and public transport. For this purpose of this paper, the main focus of VRUs is on pedestrians, cyclist, and other nonmotorized vehicles (pedicab). Meanwhile, Sweden, Germany, the Netherlands and the United Kingdom were identified as nations that have been actively addressing sustainable transportation issues for several years, especially linkages among environmental impacts, economic growth, social equality, land use and urban development (FHWA, 2001).

There are some important issues in the implementation of sustainable transport system: accessibility for reducing traffic jam, traffic safety, reducing energy and emissions and improving the life quality in the city center. Sustainable transport for VRUs is expected to be a solution to improve the quality of transportation services.

Traffic safety becomes important if it is associated with transportation for VRUs. This is due to the lack of infrastructure for VRUs, particularly on national roads, so conflicts between motorized and non-motorized vehicles are increasing on the highway.

The Study area of this research was restricted on Jalan Pahlawan and Jalan Ahmad Yani. The discussion includes the existing condition of VRU facilities, performance analysis of pedicab and bicycles, analysis of existing pedestrian facilities compared to the Geometric Design Standard for Urban Roads (1992) and The Regulation of Minister of Public Works No. 03/PRT/M/2014/2011 about Planning Guidance, Supply, and Utilization of Pedestrian Infrastructure in Urban Area and strategies that can be applied in Magelang.

The purpose of this study was to determine the condition of the current transportation system which was linked to the development of VRU facilities and public expectations of the future condition of a transport system in Magelang; analyze the performance of VRU facilities in Magelang based on facilities indicators and based on the perception of society.

2. METHODOLOGY

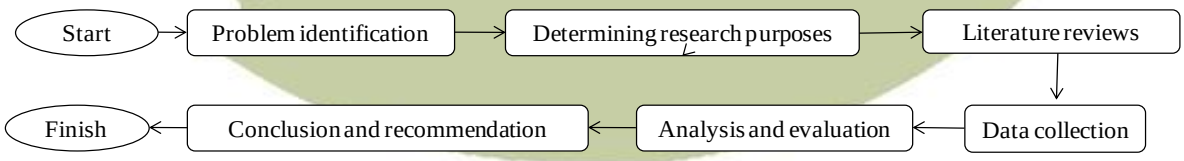

Figure 1 Research Flowchart

The identified problems in this study are: the government policies which had not been prioritizing non-motorized transport, the traffic increase due to the increasing population, the infrastructure for VRU which is lacking, the private vehicles which are

easy to be owned by the society.

Data in this study are:

1. Secondary Data: traffic data (from Department of Transportation in Magelang), the demographics/Population data (*Kota Magelang Dalam Angka* 2013), and road network data in Magelang (from Department of Public Works in Magelang), and data from the internet.
2. Primary data: survey data (including survey of origin-destination (100 respondents), roadside interview survey to cyclists, pedicabs, pedicab passengers, and pedestrians (30 respondents for each survey)) to obtain the characteristics of pedestrians and non-motorized vehicles (related to gender, age, purpose of travel, occupations, infrastructure improvement expectations for VRU, and the ownership of non-motorized vehicles.

   In addition, references from books, articles, journals and reports related to this research are needed as an additionla data.

Data analyses in this study are:

1. The descriptive statistical analysis in form of tables, graphs and charts.

2. Customer satisfaction index (CSI) method and Importance-Performance Analysis (IPA) method to assess the perception of VRU

Data collection on 30 respondents were assessed by a Likert scale 1-5

Table 1. Variables and Service Attributes

Variable	Service attributes
Reliability	Waiting time, length of journey
Responsiveness	Transport rates, traffic signs, and information boards
Assurance	Safety, assurance, security
Empathy	Driver behavior, hospitality
Tangible	Main facilities and supporting facilities

Source: Zethamal, Parasuraman, Berry (1990) in Setyawan 2012.

3. RESULTS

3.1. Characteristics of Magelang City

Magelang is one of the city in Central Java Province and at the crossing of the main transport route Semarang – Yogyakarta. Data from Department of Public Works in Magelang shows the length of national roads, provincial and municipal roads as follows:

Table 2 Length of road in Magelang (km)

National road	11,73
Province road	3,92
Local road	76,364

Source: Department of Public Works

3.2. Road and Traffic Overview at Study Areas

This research is restricted to the area of Jalan Pahlawan (with one-way traffic) and Jalan Ahmad Yani (with 2-way traffic). Both roads are parts of national roads. Road condition of Jalan Pahlawan is now equipped with the slow lane, sidewalks and the traffic signs.

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Figure 2. Existing Condition on Jalan Pahlawan

Figure 3. Existing Condition on Jalan Ahmad Yani

Jalan Ahmad Yani consists of 3 main lanes. Two lanes toward the south, one lane towards the north. Jalan Ahmad Yani is not equipped with a slow lane. Amenities such as sidewalks and pedestrian crossings with zebra cross are available in this way. The existing condition of Jalan Pahlawan has provided the slow lane facility for nonmotorized vehicles and the sidewalk, separated by a fast lane.

Geometric Design Standard for Urban Roads (1992) explains that if the nonmotorized vehicles exceed 200 bicycles per 12 hours and the traffic volume exceeds 2000 per 12 hours, bicycle lane should be provided. The survey results of traffic volume on Jalan Pahlawan and Jalan Ahmad Yani can be seen as follows:

Table 3. Traffic Volume on Jalan Pahlawan and Jalan Ahmad Yani

Time	Vehicle Type				
	Passenger Car	Public transport / Bus / Truck	Motorcycles	Nonmotorized Vehicles	
				Pedicab	Bicycle
Location: in front of Alfamart, Jalan Pahlawan, Movement Direction: South - North					
06.00 – 18.00	6655	2534	25422	98	196
	The number of motorized vehicles		**34611**	The number of non-motorized vehicles	**294**
Location: in front of Indomaret, Jalan Ahmad Yani, Movement Direction : North – South					
06.00 – 18.00	4216	2679	7694	13	22
	The number of motorized vehicles		**14589**	The number of nonmotorized vehicles	**35**
Location: in front of Indomaret, Jalan Ahmad Yani, Movement Direction : South - North					
06.00 – 18.00	656	1737	1370	19	14
	The number of motorized vehicles		**3763**	The number of nonmotorized vehicles	**33**

3.3. Trip Generation and Trip Attraction

In analyzing the trip generation and trip attraction of Magelang city, the origin-destination survey with home interviews survey was conducted first. The zoning that represents zones within the study area are:

1. Zone 1 includes kelurahan Kemirirejo, kelurahan Cacaban, kelurahan Pajang, kelurahan Rejowinangun Selatan.
2. Zone 2 includes kelurahan Potrobangsan, kelurahan Magelang, kelurahan Wates, and kelurahan Gelangan.
3. Zone 3 includes kelurahan Rejowinangun Utara, kelurahan Tidar Utara.
4. Zone 4 includes kelurahan Kramat Utara, kelurahan Kramat Selatan, kelurahan Kedungsari.

In the survey, there are several items that will be used as the variables calculation of trip generation. The dependent variable (x) is the total trip and the independent variables (y) are average income, travel modes, the average travel time, vehicle ownership, the number of respondents, and the number of family members.

Based on the correlation analysis of x and y variables; variables that have rational influence of Y are X2 (the number of family members), X12 (bicycle ownership), X13 (motorcycles ownership) and X14 (car ownership). The result of multiple regression formula is as follows:

$$Y = 0.531798 + 0.513158\ X2 + 0.591557X12 + 0.202421\ X13 + 0.502504X14 \quad (1)$$

3.4. Trip Distribution

Based on the origin-destination surveys, it can be observed that the movements are movement between internal cordon and external cordon, and between external cordon and internal cordon. Internal cordon is the area in zone 1, zone 2, zone 3, and zone 4 while external cordon is the area outside Magelang city. The result of origin-destination data by percentage are given in Table 4.

Table 4. Origin Zone and Destination Zone Distribution in Precentages

Origin	**Destination**				
	Zone 1	Zone 2	Zone 3	Zone 4	External Cordon
Zone 1	77%	11%	4%	1%	7%
Zone 2	17%	68%	4%	3%	8%
Zone 3	2%	7%	60%	0%	10%
Zone 4	8%	9%	6%	65%	12%

Majority movements are short distance movements (in the same zone).

3.5. Mode Choice

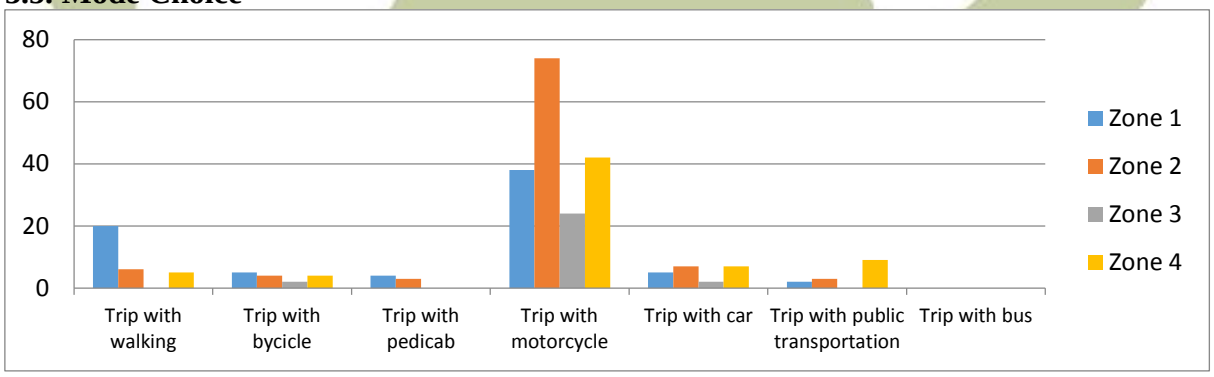

Figure 4. Mode Choice for Each Zone by Bar Chart

Walking activity can be correlated with the level of resident income. 46% of respondents who earn less than 2 million rupiahs per month frequently walk to their work place. The majority of people prefer using motorcycles to travel from one place to another place.

The majority of respondents (55% respondents) earn less than 2 million per month, but the trip by motorcycle found as many as 67% of the total trips. The use of motorcycles is also supported by the availability of off-street parking. Data survey showed that 79% of respondents parked his vehicle outside the road (off street parking) and 21% of respondents parked his vehicle on the side of the road (on street parking).

3.6. Vehicle Ownership (Motorized and Nonmotorized)

Motorized and nonmotorized vehicles ownership can be divided into bicycles, motorcycles, and cars ownership. Based on data, bicycle ownership in zone 2 is the highest. Motorcycle ownership for all zones is the highest compared to bicycle and car ownership.

3.7. Characteristics of Vulnerable Road Users

3.7.1.Characteristics of Pedicab Drivers

The number of pedicabs in Magelang based on information from the Department of Transportation was 167 pedicabs. The survey was conducted on 30 pedicab drivers. All pedicab drivers are male. The age of pedicab drivers varies from 38 years to 64 years old. The majority of pedicab drivers were elderly (over 50 years old).

3.7.2. Characteristics of Pedicab Passengers

The survey was conducted on 30 respondents to determine the characteristics of pedicab passengers. Based on survey, the characteristics of pedicab passengers are presented in Table 5 as follows:

Table 5. The Characteristics of Pedicab Passengers

Numb	Variable	Description
1	Gender	Male= 30%, female= 70%
2	Age (year old)	<20 = 23,34%, 21-40 = 23,34 , 41-60 = 43,33 % >61 = 10%
3	Occupation	Student = 26,67%, Civil servant = 6,67%, Pensionary = 16,67%, Private employee = 16,67 %, Tradesman = 20%, Housewife= 13,33%
4	Income (million)	<0,5 = 13,64, 0,5- 1 = 27,27 %, 1-2 = 45,45%, 2-3 = 13,64%
5	Trip purpose	Study at school = 26,67%, Work = 23,33%, Shopping = 36,67 %, Etc = 13,23%
6	Trip frequency	Once a week = 40%, Twice a week = 53,33%, Three times a week= 6,67 %
7	Car ownership	Do not have = 60 %, 1 car = 30%, 2 cars = 10%
8	Motorcycle ownership	Do not have= 25%, 1 motor =43,75 % , 2 motor = 12,50%,3 motor = 6, 25%, > 3 motor = 12,50%

3.7.3. Characteristics of Pedestrian

The survey was conducted on 30 pedestrian respondents in order to know the pedestrian characteristics. Based on the survey, the characteristics of pedestrian are presented in Table 6 as follows:

Table 6. The Characteristics of Pedestrian

Numb	Variable	Description
1	Gender	Male = 46,67%, Female = 53,33%
2	Age (year old)	<20 = 40%, 21-40 = 20%, 41-60 = 20 % , >61 = 10%
3	Occupation	Student = 40%, civil servant= 6,67%, Pensionary = 33,33%, Private employee = 3,33%, Tradesman = 3,33%, Housewife= 13,33%

Numb	Variable	Description
4	Income (million)	<0,5 = 15,38, 0,5- 1 = 23,07 %, 2-3 = 23,07%, 3-4 = 30,76%, >4= 7,72 %
5	Trip purpose	Study = 13,33%, Work = 13,33%, Shopping = 16,67 %, Etc = 6,67%, Physical exersice = 50%
6	Trip frequencues	Once a week = 40,9%, Twice a week= 22,73%, Three times a week = 13,673%, Four times a week= 0,09%, everyday= 13,64%
7	Car ownership	Do not have= 84,21,%, 1 car= 15,79%
8	Motorcycle ownership	Do not have= 43,33%, 1 motorcycle= 6,67 %, 2 motorcycle= 26,67%, 3 motorcycle= 23,33%

3.7.4. Characteristics of Cyclist

The survey was conducted on 30 respondents to determine the characteristics of cyclist. Based on the survey, the characteristics of cyclist are presented in Table 7 as follows:

Table 7. The Characteristics of Cyclist

Numb	Variable	Description
1	Gender	Male = 60%, Female = 40%
2	Age (year old)	<20 = 27%, 21-40 = 40%, 41-60 = 23 % , >61 = 10%
3	Occupation	Student = 27%, civil servant= 10%, Pensionary = 10%, Private employee = 23%, police/army = 3%, Tradesman = 13%, Housewife= 13%
4	Income (million)	<0,5 = 40%, 0,5- 1 = 13 %, 2-3 = 10%, 3-4 = 10%, >4= 20 %
5	Trip purpose	Study = 13%, Work = 3%, Shopping = 10 %, Etc = 3%, Physical exersice = 70%
6	Trip frequencues	Once a week = 33%, Twice a week= 17%, Three times a week = 23%, Four times a week= 17%, Five times a week 3%, everyday= 10%
7	Car ownership	Do not have= 53,%, 1 car= 37%, 2 cars = 10%
8	Motorcycle ownership	Do not have= 0%, 1 motorcycle= 50 %, 2 motorcycle= 43%, 3 motorcycle= 7%

3.8. Pedicabs Performance

The pedicab drivers usually work from 6 a.m. or 8 a.m. for 6 to 8 hours. 50% of the surveyed pedicab drivers only served 3 to 5 passengers a day. The average distance for each passenger typically 0-5 km (short distance). With a relatively small number of passengers, the majority of the total distance in a day is less than 10 km. 87% of pedicab drivers' income is only less than Rp 50.000,00 a day. The peak hours occurred at 5 p.m. until 6 p.m. The busiest day was on Sunday (46%). From the interviews it is identified that some of the problems that were frequently encountered by pedicab drivers are as follows:

1. Human factor: Pedicab drivers were not strong enough to ride their vehicles due to the age factor.
2. Vehicle factor: leaky tires, the old pedicabs.
3. Road factor: There were no special lines for pedicabs (slow lane) in some roads; the steep vertical alignment of the road often causes the fatigue condition of the drivers; slow lane in some roads is often used by motorcycle.
4. Difficult operation factor: The decrease number of passengers; difficulty to get passengers, the competition between pedicabs and private vehicles, public transportation, and taxi.

3.9. The Analysis Result of Vulnerable Road Users Facilities

The analysis result of VRU facilities based on the predetermined indicators are described as follows:

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Table 8. VRU Facilities Analysis Result Based on Indicators

No	Variables	Indicators	Description
1	Pedestrian facilities	5 – 7 feet width	There is a sidewalk with 5-7 feet width, but not all sidewalks meet this criteria(in front of Magelang Radio Office Jalan Pahlawan)
		On trade and the downtown location have 8-12 feet width	Sidewalks in the trade center have 12 feet width
		Having completeness plants, bench and lighting	There is a sidewalk that has a complete street furniture, but not all sidewalks have such completeness.
2	Cyclist and Pedicab facilities	Integrated non-motorized paths network	Not have an integrated non-motorized path
		Has a parking space in the public areas and the city center	Not have a particular bicycle parking and pedicab parking in public places
		Having an event (for bicycle) that is conducted regularly	There is car free day event every Sunday morning at Alun-Alun and Rindam
		Having a barrier as a security function	There are roads that have dividers (Jalan Pahlawan) but not all the bike line has a barrier (Jalan Ahmad Yani doesn't have slow lane)

3.10. The Perception Analysis of Pedestrian and Cyclist

The calculation of pedestrian perceptions, cyclists, and road crosser pedestrians was conducted to get the Customer Satisfaction Index (CSI) value. A value of 1 means very dissatisfied, 2 means not satisfied, 3 means quite satisfied, 4 means satisfied, and 5 means very satisfied.

Cyclists Respondents were quite satisfied with the completeness of the traffic signs, the ease of the crossing road, the condition of traffic calming and the condition of the slow lane. Pedestrians and road crosser pedestrians were satisfied with the ease of crossing road and sidewalk conditions.

On average, pedicabs passengers were satisfied with the pedicabs services (rates, duration, waiting time, availability, driver behavior, safety, cleanliness, eligibility). Comfort attribute was the lowest perceived value (quite satisfied).

3.11. Importance Performance Analysis (IPA)

Importance Performance Analysis (IPA) is used in the survey data to describe the perception and expectations of respondents on several factors (reliability, responsiveness, assurance, empathy and tangibility). The results of the research presented in the form of two-dimensional graphical quadrant are easily interpretable.

Responsiveness indicators of cyclists, pedestrian, and pedicab passengers were located in the 3rd quadrant indicating the low priority. Responsiveness Indicators has a low level of actual performance, it is not so important for the policy makers to prioritize or give attention to the responsiveness indicator.

Reliability and assurance indicators are located in 4th quadrant, which is not too important for the relevant parties to allocate resources and guarantee the reliability factor related to other sectors that still need improvement.

4. DISCUSSION

Jalan Pahlawan has provided the slow lane for nonmotorized vehicles and the sidewalk, which are separated by a fast track. Jalan Ahmad Yani has a few traffic of non

motorized vehicle mode. For safety reason, it should have provided slow lane facilities. The usage of special markers of nonmotorized vehicle lane can be an alternative to increase the safety and comfort in driving nonmotorized vehicles.

Traffic calming strategies need to be applied in Jalan Pahlawan and Jalan Ahmad Yani to improve the safety of vulnerable road users using speed limitation signs, speed bumps and rumble strips. Before zebra cross, especially in the area of Jalan Pahlawan with many schools along the road, it's needed to add thebschool zone with striking colors and rumble strips. Rumble strips can be applied before zebra cross, for example in the parking area. Reduction of speed approaching the intersection (*Balai Pelajar intersection*) can be done by adding the slowly down marker.

Improving sidewalk comfort can be done by repairing sidewalks defect and adding the lighting. Sidewalks at Jalan Pahlawan, exactly in front of Badaan parks, have been equipped with lights. However, most of the sidewalks in Jalan Ahmad Yani and Jalan Pahlawan still have obstacles, especially from the traders who sell their stuffs on the sidewalks and the slow lane. It needs strict controls to curb traders in this sidewalk and municipality should give proper place to accommodate the street traders.

Park and road facilities are needed to be developed in Magelang to improve the ease of long distance trips and to accommodate the public transport usage, with door to door service. Bicycles can be parked at the bus stop and then the cyclists may use the public transport. Thus, intermodal transport linkages can be established. For short distance trips, the usage of motorbike needs to be minimized and replaced by non-motorized vehicles using comfortable slow lane and without interruption. As the result of the analysis of trip distribution, the majority of respondents traveled in the same zone which means that the trip was conducted in a short distance.

The use of non-motorized transport needs to be improved. According to the results of the study, the highest motorcycle ownership is owned by the respondents. Their motorcycles are the main obstacle to the use of non-motorized vehicles. Some events to increase the bicycle use, such as car-free day, bike to work campaign, bike to school campaign need to be improved; and for long distance travel, the use of public transport can be a solution. To be able to compete with the use of motorcycles, public transport subsidies are absolutely necessary so that the cost of transportation by public transport can be reasonable and can compete with the motorcycles.

A safe and comfortable bus stop, convenient public transportation, the certain arrival and departure schedule of public transport and low price public transport can become solutions for reducing the usage of private vehicles, especially motorcycles. Studies of public transport in Magelang had been implemented in other studies with the result of improved public transport route bus lanes 1-12 and the procurement of trans Magelang A and B.

The pedestrian bridge is not required to be applied in Jalan Pahlawan and Jalan Ahmad Yani since the construction is expensive yet the usage by pedestrians in some cities is low and it does not support the elderly or children. The use of pedicabs can continue to support sustainable transport in the city of Magelang (no need for a ban on pedicabs like in big cities).

5. CONCLUSION

Based on the result and discussion, the variables that affect the number of trips in Magelang are the number of family members, bicycle ownership, motorcycle ownership

and car ownership. Meanwhile, the majority movement is movement within a short distance (within the same zone). Motorcycle ownership at the observed zone is the highest. 67% of respondents who earn less than 2 million rupiahs per month have a motorcycle. Motorcycle became the main obstacle for vulnerable road users.

In the operation of pedicabs, barriers experienced by pedicab drivers and passengers are the human factor, vehicle factor, the road defect, difficulty in obtaining passenger, and the time factor. Facilities for vulnerable road users are already available and meet the indicators, but have not yet implemented across the roads. Jalan Pahlawan has a slow lane and has high non-motorized vehicle traffic while Jalan Ahmad Yani does not have the slow lane and has low nonmotorized vehicles traffic. IPA analysis included in quadrant 3 and 4, which means low priority and not too important so that stakeholders need to allocate resources, guarantee, and reliability factor to other sectors that still need improvement. On average, the respondents are satisfied or fairly satisfied with the existing facilities.

To improve comfort and safety for vulnerable road users, the VRU facilities improvements are needed (additional markings, traffic calming, repair defect sidewalks, the addition of a sidewalk lights, bench, strict controls to curb traders along the slow lane and sidewalks). To increase the use of non-motorized transport, it is advisable to increase the parking area and ride facilities and to improve the public transport both in quality and quantity.

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