

PRIORITY ACTION PROGRAMS OF PUBLIC TRANSPORTATION IN DEVELOPING SUSTAINABLE CITY IN INDONESIA

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ABSTRACT: Public transportation in Indonesia experiences a number of challenges, for example, low density of road network, increased number of vehicles annually, paratransit domination in the city, limited number of MRT available, poor traffic regulation adherence, and poor land-use arrangement. Based on the conditions, sustainable transportation as a part of a sustainable city cannot be reached soon. The study aims are to determine priority action programs of sustainable public transportation in developing a sustainable city in Indonesia. A number of case studies regarding many public transportation modes i.e. Padalarang-Bandung-Cicalengka electric train, bus public transportation in Yogyakarta, Pekanbaru, and Bandung, and ITS implementation in Bandung. More than 800 respondents involved in these case studies. A number of methods including UCL Method, Important Performance Analysis, Quadrant Analysis, hetero-hedasticity, multi-collinearity, validity, normality, reliability, and multiple regression used in analyzing a large number of field data. Results studies are priority action programs of sustainable public transportation in developing sustainable city in Indonesia i.e. developing: safe, secure, comfortable, and cheap public transportation, car free-day, car-pooling, cycling, walking, ride-sharing, integrated public transportation modes, good land use management, and good maintenance and improvement of ATCS as a part of ITS.

Keywords: Priority action programs, Sustainable public transportation, Sustainable city, Indonesia

1. INTRODUCTION

Large cities in Indonesia usually experience traffic congestion. One way to reduce traffic congestion is the implementation of public transportation. As the main transportation system, public transportation in an urban and rural area has to operate in a secure, safe, comfortable, cheap, fast, and accessible.

However, existing public transportation in Indonesia experience many challenges i.e. few numbers of mass rapid transit but various numbers of size, capacity, level of service of public transportation modes, road users do not adhere to the traffic regulation, and limited road network density [1]. Based on these existing conditions, priority actions to be sustainable transportation is needed. The aim of this study is to determine priority action programs of sustainable public transportation in developing a sustainable city in Indonesia.

Case studies of existing public transportation are carried out at many public transportations modes in many cities and road segments in Indonesia. Other large cities in Indonesia and in other developing countries with similar conditions can also implement these results of this study.

Nowadays, more than half of the population in the world lives in cities. In 2050, 80 percent of the population lives in the cities because of urbanization. Therefore, in the future, not only urban planning that has to be managed, but also how to make the cities sustainable.

In the 21st century, all social activities in cities in a developing world are the most rapid in growth. These challenges will lead to severe process towards sustainable cities. Furthermore, political vision and leadership are needed to support a sustainable city through integrated vision, programs, and projects development [2],[3].

There are many explanations regarding the sustainable city, for example:

- The sustainable city is a city with sustainable and long term of ecological and socio-economically activities that have a low impact on the environment. The emphasizes is the importance of infrastructure development including urban ecosystem management, waste management, building design, transportation, energy, water, and food systems – and how to integrate among sectors [2].
- A sustainable city is a city with the most important aspects of climate action, and evaluation that consists of carbon measurement and planning, urban transportation, waste management, and sustainable communities. Moreover, implementation regarding sustainable

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energy, cap and trade, excellent public transportation, a zero-waste program, and effective road management has to be done by municipalities [4].

- Sustainable (urban) city based on the Brundtland Commission is regarding that the present development will not cause difficulty to the future development to meet their own needs" and it is according to the URBAN21 Conference [5].

It can be seen that sustainable public transportation is an important part and needed in developing a sustainable city. Furthermore, because of the different existing condition among cities in developed or developing countries, the priority actions program to be implemented would be different from one city to another, even in the same developing country.

Public transportation is needed by society, in order to support a number of social and economic activities, for example, going to work, to study, and to shop. Among a number of definitions explaining sustainable public transportation, sustainable transportation can be defined as the transport and mobility that concern to the local and global environment by using renewable fuels and minimizing pollution emissions, the lower cost towards green transport, reduce traffic congestion, light injuries, heavy injuries, and fatalities. Moreover, this condition improves the life quality of society [6], [7].

3. EXISTING PUBLIC TRANSPORTATION IN INDONESIA

3.1 Public Transportation in Indonesia

A number of modes of public transportation operate in Indonesia in order to serve the society i.e. train, bus, paratransit, boat, ship, and airplane. Rail is the oldest transportation mode. It was developed in 1864 and operated in 1867 in Java Island with 26 km long between two villages, Kemijen and Tanggung. Tract width used is 1,435 mm. Then, many provinces in Indonesia operate the railway, in 1874 in Aceh, in 1886 in North Sumatera, in 1891 in West Sumatera, in 1914 in South Sumatera, and in 1922 along Makasar-Takalar, Sulawesi.

Nowadays, in Java and Sumatra islands, the railway operates with 1,067 m tract width and implements Information, Communication, and Technology (ICT) for an online ticket to serve passenger train and cargo train [8]. Soon, 142 km railway long will operate a high-speed train connecting Jakarta and Bandung in West Java. The train travel time will be only around 45 minutes compares to bus travel time that around two hours

through toll road if there is no traffic congestion.

Bus as public transportation mode operates in a number of large cities in Indonesia. There are Trans Jakarta, Trans Metro Bandung, Trans Pakuan in Bogor city, Trans Metro Pekanbaru in Pekanbaru city, Trans Musi in Palembang, Trans Semarang, Trans Yogyakarta, Trans Batik Solo, Trans Surabaya, and Trans Kawanua in Manado, Sulawesi.

Besides bus that only operates in large cities, there is paratransit that operates not only in large cities but also in towns in Indonesia. Paratransit capacity is only 10 passengers but it is the largest number of public transportation in the city and town and also dominates most of the public transportation routes in the city and town.

Other public transportations operate in Indonesia are boats, for example, those on Musi river in Palembang, South Sumatra Province and those on Barito river and Martapura river in Banjarmasin, South Kalimantan Province. Besides that, there are ships and airplanes that operate among large cities that have harbor and airport.

3.2 Public Transportation Challenges in Indonesia

Although in Indonesia all modes of public transportation operate together, traffic congestion is still occurring in the cities because of a number of existing reasons, for examples:

- Only a few numbers of mass rapid transit (MRT) operates to carry a large number of people and goods.
- Many kinds of capacity and level of service of the existing public transportations.
- Domination of paratransit as public transportation in the city, with a number of complicated problems including not good of car condition, level of service, traffic regulation adherence (paratransit has no fixed timetable and has no shelter), and route conflict with other public transportation.
- Traffic violation by drivers, passenger, and pedestrian as road users.
- The small ratio between road network density and city area, wherein improving the road facility physically is not a priority.
- High increase in vehicles number cannot be counterbalanced by a low increase in road network physically.
- Not good land use arrangement and management in the city lead to serious traffic congestion.

Most of society usually use passenger car because of complicated existing conditions. The important thing is the implementation of priority action programs determined soon to reach sustainable public transportation as a part of a sustainable city.

4. METHODS

A number of research studies towards sustainable transportation have to be done in order to decide whether sustainable transportation condition has been reached or not. Therefore, research methodology is needed to develop so that data and analysis can be determined and the results of the study can be obtained correctly.

4.1 Methodology

The research methodology is presented in Figure 1. After doing all the systematic steps of the methodology, then the important thing is the implementation of the priority action programs soon continuously and consistently. Furthermore, the performance of priority action programs implementation needs an audit in order to have a better result in the future.

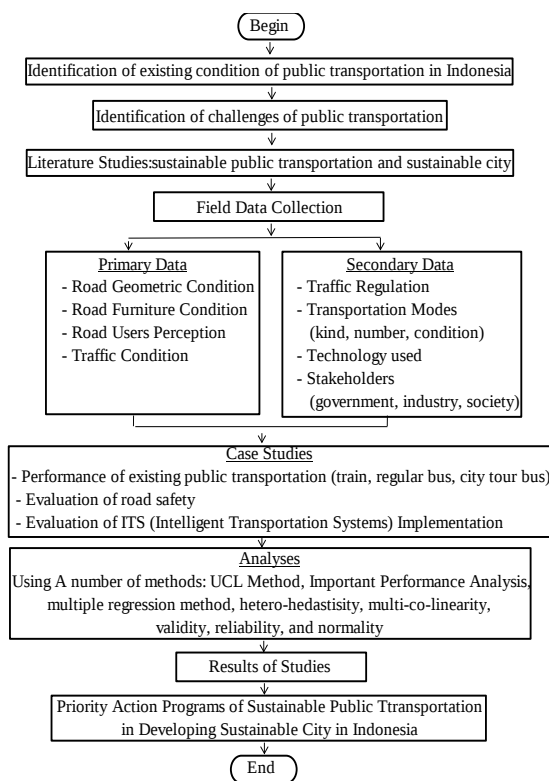


Fig.1 Research methodology to determine priority action programs of sustainable public transportation

4.2 Data and Analysis of Public Transportation Modes Performance

Analysis of a number of studies regarding service rate and performance of existing public transportation is presented in Table 1 and detail analyses are presented in Figure 2 up to Figure 6 and Table 2 [9], [10], [11], [12]. Figure 2 up to Figure 4 are the analysis result of existing performance of Padalarang-Cicalengka electric train in West Java Indonesia. In more detail, Figure 2 presents electric train passenger demand per day. Then with this demand, analysis of headway needed based on the line capacity with load factor equal to 1 during peak and off peak hour presented in Figure 3 is much longer than headway value based on operational speed and safety factor that presented in Figure 4. This means that the performance of electric train has to be increased.

Furthermore, Figure 5 presents relationship analysis between Importance Rate and Service Rate of safe, secure, and comfort of Bus Trans Metro Pekanbaru in Riau Province, Indonesia using Importance Performance Analysis and Quadrant Analysis and Figure 6 presents relationship analysis between Importance Rate and Satisfaction Rate of safe, secure, and comfort of Bus Trans Yogya, in Centre Java province, using Importance Performance Analysis and Quadrant Analysis. It can be seen in Figure 5 and Figure 6 that not all of service and satisfaction rate is good (value = 4) and need to be increased.

These studies are important because safe, secure, and comfortable public transportation is going to move people from using passenger car to public transportation. If this condition occurs, then traffic congestion will reduce significantly.

The results studies show that public transportation including train and bus still not reaches the minimum service standard required and need to be increased toward sustainable public transportation.

4.3 Data and Analysis of Road Safety Evaluation

Studies regarding road safety are important because data record indicated that 90% of the deaths are in low and middle-income countries with one million three hundred people died worldwide each year and [13], [14]. The aims of these case studies are to determine blackspot locations and furthermore, to determine important factors that cause the accident in order to deliver recommended solutions to increase safer road in Indonesia.

The case study was conducted on Purbaleunyi (Purwakarta-Bandung-Cileunyi) toll road as a national road in West Java Indonesia. This road is selected because other roads with road function as an arterial road, collector road, and local road have not accident data record with enough completeness, accuracy, and up to date requirements.

Purbaleunyi toll road connected Jakarta, and Bandung in West Java. It is a 123 km long road with two direction and four lanes (4/2D), 5 bridges, and operates with 60 km/h to 80 km/h speed limit. This toll road, as national road, fulfill the geometric requirements i.e. lane width = 3.6 m, outer shoulder width = 2.75 m, inner shoulder-width = 0.75 m, and median width = 3.5 m [15].

Data of accident and important factors that cause the accident and locations of blackspot on Purbaleunyi toll road are presented in Table 3. Table 3 shows that the toll road, that fulfilled all geometric standard and road furniture standards, still has a high number of accidents and fatality occur each year.

Accident rate and UCL (Upper Control Limit) methods can be used to determined blackspot location on the other road networks if data of the accident is complete and accurate. Then, further treatment can be done to reduce accident number and accident fatality.

A number of solutions can be recommended i.e. deliver information regarding safer road importance to road users, good installation of road furniture, consistent road audit, and Intelligent Transpotatio Systems implementation [15], [16], [17], [18], [19], [20].

4.4 Data and Analysis of ITS Implementation

Advanced traffic control systems (ATCS) as a part of Intelligent Transportation Systems (ITS) were implemented in Bandung, Indonesia. in June 1997, as a pilot project. ATCS was implemented at all 117 signalized intersection in Bandung. Therefore, the performance of ATCS in a large city in Indonesia that has many specific conditions is crucial to evaluate. Summary of a number of ATCS implementation studies regarding the bad impact on the environment including pollution emission, fuel consumption, and traffic congestion, in Bandung Indonesia are presented in Table 4 [21].

Table 4 indicated that implementation of ATCS in June 1997 in Bandung cannot increase the performance of traffic and has no good impact on the environment, because of the existing conditions.

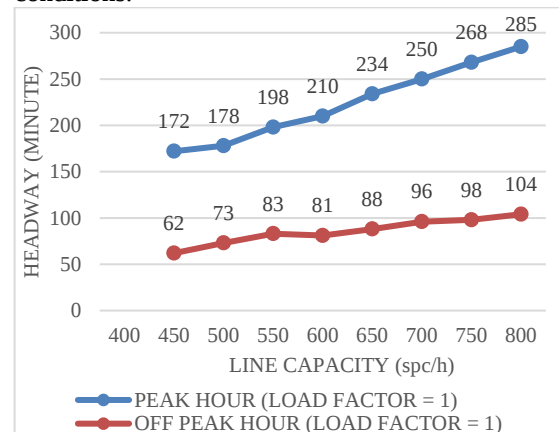


Fig.3 Analysis of headway value based on the line capacity

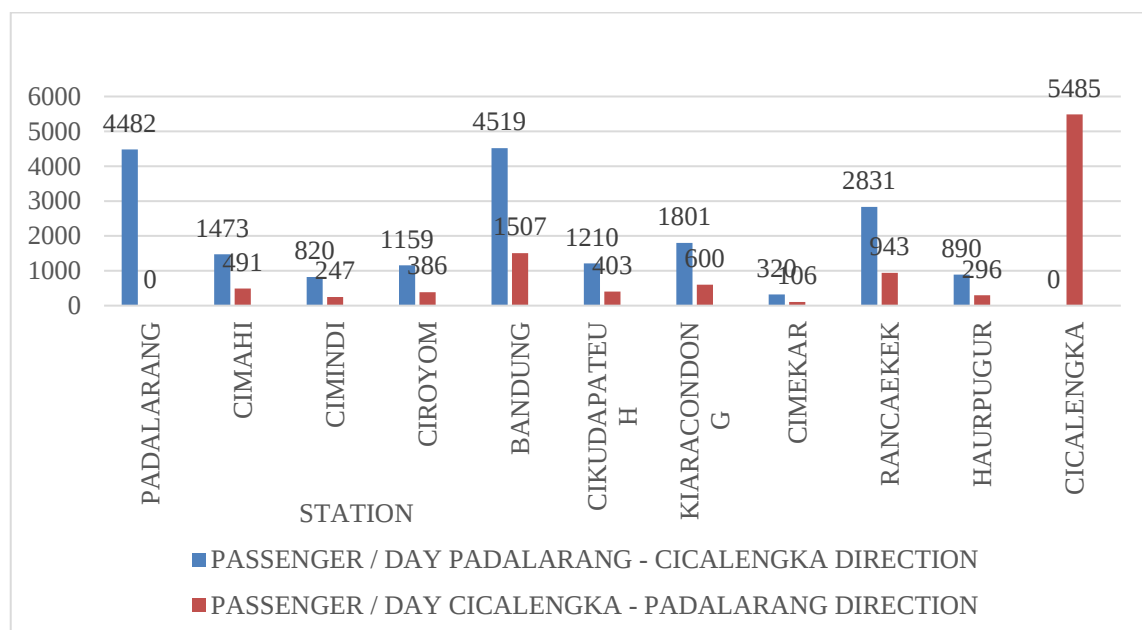


Fig.2 Electric train passenger demand

Table 1 Performance of existing public transportation performance (train, regular bus, city tour bus)

Public Transportation Mode	Existing Condition (Primary and Secondary Data)	Challenges/Objectives	Analysis	Results Study
Electric Train as a mass rapid transit Padalarang – Bandung Cicalengka (P-B-C) [9].	- Operated in 2010. - Diesel train used on 42 km railway long. - Train operation speed is 60 km/h– 90 km/h and acceleration and deceleration value is 0.8 m/sec² - Rail width is 1.067 m.	- To evaluate service performance. - To determine the headway based on passenger demand.	- Headway is analyzed base on: - passenger demand. - appropriate load factor. - limit of train speed. - safe stopping distance. - and dwell time factor during peak and off peak hours. In more detail, presented in Figure 2 up to Figure 5.	- Peak hour: 51 minutes headway. - Off Peak hour: 140 minutes headway.
Regular Bus Trans Metro in Pekanbaru, capital city of Riau Province, Sumatra [10].	- Operated in 2009. - Route I: 33 km, 52 bus stops, 10 buses, 700 m length between bus stop. - Route I: 42 km, 42 bus stops, 10 buses, 700 m length between bus stop.	- To determine service rate of public transportation. - To evaluate performance of public transportation.	Service rate and performance of public transportation is analyzed by Important. Performance Analysis Method 100 passengers of all routes involved in this study as respondents In more detail, presented in Figure 6.	- Bus Trans Metro Pekanbaru service rate is more than 3 of 5 besides security in shelters (2.66) - Highest values in importance rate are pollution-emission and comfortability. - Highest value in satisfaction rate are officer hospitality , location of shelters, and bus ticket price.
Regular Bus Trans in Yogyakarta, Cental Java [11].	- Operated in 2008. - Number of route is 6 routes. - Number of bus stop is 112 bus stops. - Number of fleet is 54 buses in 2008 and 74 buses in 2010.	- To determine service rate of public transportation. - To evaluate performance of public transportation.	Service rate and performance of public transportation is analyzed by Quadrant. Analysis Method 430 passengers of all routes involved as respondents. In more detail, presented in Figure 7.	Bus Trans Jogja Performance, for all six routes and 112 shelters fulfilled 24r out of 27 standards of minimum services standards besides waiting time and dense crowd of passenger in shelter, and passenger dense crowd in the bus.
Werkudara City Bus Tour in Surakarta, Cental Java [12].	- The first double deck city bus tour in Indonesia that operated in 2011. - Bus operates two times a day, 9:00 am-11:00 am and 2:00 pm 4:00 pm with ticket price is 1.3 €	To determine important factors of city bus tour service quality.	Data was collected in March 2016, 58 tourists as responden are involved in preliminary survey (for validity and reliability of questionnaire) 148 tourists as respondents are involved in this study. Based on customer satisfaction service quality important facto is determined using Multiple Regression Method. Statistical tests conducted to ensure the questionnaire are hetero-hedastisity, multi-co-linearity, validity, reliability, normality, and multiple regression method. The results are as follow: Validity Test, r value > 0.2586 (less than 0.05) à valid Reliability Test, Cronbach's Alfa avg value 0.870 (more than 0.60) à reliable.	- Result equation indicates that the authority. has to increase the important factors i.e. - X1 = reliability - X2 = decrease responsiveness - X3 = assurance - X4 = empathy - X5 = tangibles

Table 2 Analysis of headway based on dwell time for two directions

Road Corridor	Peak Hour Headway (minute)		Off-Peak Hour Headway (minute)	
	P-B-C	C-B-P	P-B-C	C-B-P
Padalarang	9.5	0	3.8	0
Cimahi	3.4	1.5	1.6	0.9
Cimindi	2.1	1.0	1.1	0.7
Ciroyom	2.8	1.3	1.3	0.8
Bandung	9.5	3.5	3.8	1.6
Cikudapateuh	3.0	1.3	1.4	0.8
Kiaracandong	4.1	1.7	1.8	0.9
Cimekar	1.1	0.7	0.7	0.6
Rancaekek	6.2	2.4	2.6	1.2
Haur Pugur	2.3	1.1	1.2	0.7
Cicalengka	0	11.5	0	4.5

Table 4 ATCS impact on traffic congestion, fuel consumption, pollution emission to the environment in Bandung city, Indonesia [21]

Performance Parameters (average)	Operation of ATCS	Fixed Time Traffic Control System
Traffic Flow (veh/h)	1,916	1,950
Queue Length (veh)	37	31
Density (veh/km)	17	16
Speed (km/h)	29	40
Travel Time (mm:ss)	4:55	4:33
Delay Time (mm:ss)	3:11	2:49
Stop Time (mm:ss)	3:1	2:39
Stops (stops/km)	3	3
Fuel consumption (liter)		
Morning Peak	4,898	4,878
Off-Peak	4,202	4,070
Afternoon Peak	4,617	4,383
Pollution Emission (NO _x , CO, HC kg)		
Morning Peak	372;315;1,003	337; 285; 909
Off-Peak	307; 259; 827	309; 261; 833
Afternoon Peak	315; 266; 848	308; 261; 831

Table 3 Accident data, location of black spot, and important factors that cause the accident on Purbaluenyi Toll Road [15,16,17,18]

Data and Analysis of Accident	Year	
	2010	2011
Average Daily Traffic (ADT) (veh/direction)	25,913	33,509
Road crashes number	295	307
People involved number	636	573
Road segment number	10	10
Light injuries percentage	64	57
Heavy injuries percentage	30	34
Fatality percentage	6	9
Human error percentage	70	79
Vehicle error percentage	25	20
Road merging, exhaust fumes, stopped car percentage	5	1
$T_k = \frac{(F_k \times 10^8)(100\text{JPKP})}{L \times n \times LHR \times 365}$ T_k = 100 JPKP accident rate F_k = frequency of accident during n year on road segment LHR = average daily traffic volume (ADT) n = number of year data L = road segment length, km 100JPKP = dimension of rate accident (accident number/ 100 of vehicle travel/ km)		
UCL		
$= x + (2.576\sqrt{\frac{x}{m}} + \left(\frac{0.829}{m}\right) + \left(\frac{1}{2}\right)m$	12.92	9.79
UCL= Upper Control Limit x = accident rate mean in accident dimension /exposure m = exposure dimension, km		
Number and location of blackspot	4	3
A = Jakarta to Bandung direction, km	A:69-70	A:69-70
B = Bandung to Jakarta direction, km	A:75-76	A:72-73
	B:70-71	B:73-74
	B:77-74	

Important factors that cause the accident are 75 percent human error, 22 percent vehicle, 2 percent road geometric, and 75 percent occurs at clear weather.

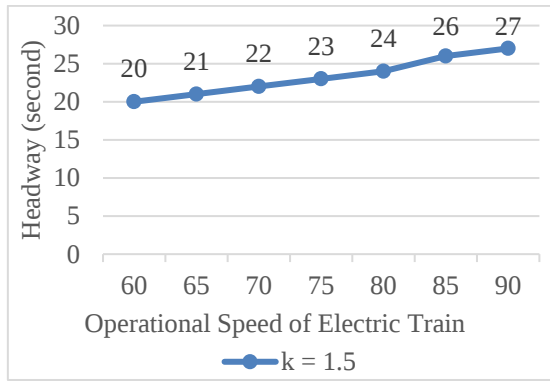


Fig.4 Analysis of headway value based on operational speed and safety factor

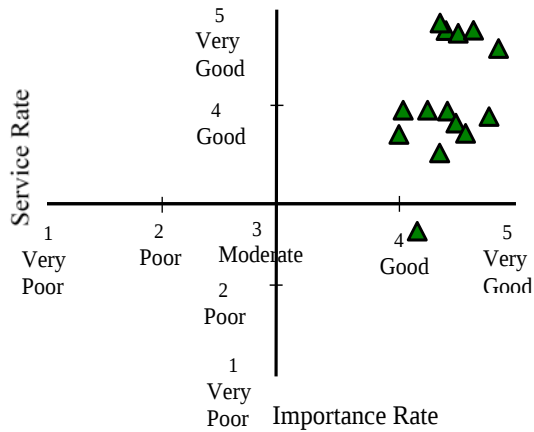


Fig.5 Relationship between Importance Rate and Service Rate of Bus Trans Metro Pekanbaru using Importance Performance Analysis and Quadrant Analysis

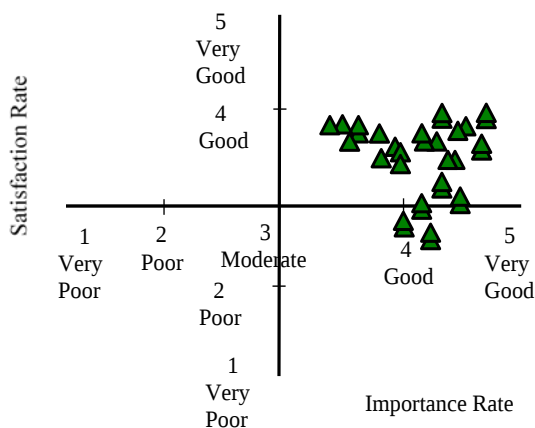


Fig.6 Relationship between Importance Rate and Service Rate of Bus Trans Yogya using Importance Performance Analysis and Quadrant Analysis

5. RESULTS AND DISCUSSION

Based on specific conditions and results studies, the recommended solutions are as follow:

5.1 Recommended Solution for Public Transportation Modes

The recommended solutions to improve the operation of public transportation modes are as follow:

- Fixed route and time table of buses and paratransit as public transportation modes in the city. They should not stop anywhere and anytime along the street.
- An adequate number of the bus as public transportation, in a good condition and level of service.
- An adequate number of the bus stop, terminal, and feeder in a safe, secure, and convenience condition.
- Availability and an adequate number of goods and low-cost ticketing management.

The recommended solutions to improve the management of public transportation modes are as follow:

- Integrated mass rapid transit (MRT) i.e. bus and train.
- Integrated operation of railway, waterway, and road way.
- Improving the green public transportation system with low ticket fare that has a low impact on the environment.
- Facilities of car free-day, car-pooling, cycling, walking, and ride-sharing.

5.2 Recommended Solution for Traffic Conditions Including Road Safety

The recommended solutions are as follow:

- Determination of locations of blackspot, deficiency of safety, and consistent safer road audit by road authority to reduce accident number and accident fatality.
- The discipline of road users to parking regulation marking regulation, and control to street vendor activities.
- Fulfillment of road furniture in the city.
- Consistent and continuous action to disseminate information about road safety importance to a scholar at primary, secondary, and high school since the beginning.

5.3 Recommended Solution for ITS Implementation

The recommended solutions are as follow:

- Good maintenance of ATMS (Advanced Traffic Control Systems) implementation in a number of

cities, for example in Bandung and Surabaya [21].

- Improvement of implementation of Advanced Traffic Control System (ATCS), including VMS (variable message signs) implementation and integrated existing public transportation using ITS.

Moreover, because all of the recommended solutions cannot be implemented in time, priority action programs are needed. The local and national government have to work hard to reach sustainable public transportation in developing a sustainable city. Vision formulation, mission formulation, policy formulation, concept formulation, regulation, and detail direction of actions is crucial. The priority action programs are different between one a city to another and also different from one country to another, especially between those in developing and developed countries. Based on existing conditions in large cities in Indonesia, the steps of priority action programs are as follow and presented in Figure 7.

- Formulate the vision and mission of sustainable public transportation implementation by government or city mayor.
- Determine the existing condition of public transportation.
- Collect all existing regulations.
- Evaluate the existing conditions regularly through studies.
- Provide recommendation as results studies.
- Provide priority action programs and cooperation among stakeholders i.e. government, industry, and society.
- Improve the existing condition of public transportation by the implementation of the priority action programs.
- Audit of public transportation performance regularly.
- Repeat all the steps systematically.

6. CONCLUSION

Public transportation existing conditions and specific conditions of an urban area in developing countries are specific. Furthermore, all conditions make the implementation of sustainable public transportation in developing a sustainable city is not an easy task to do, especially in a short time. Priority action programs as results of a number of studies should be implemented continuously and consistently, and should then be supported by vision, mission, policy, concept, regulation, and direction, regarding sustainable public transportation in developing a sustainable city. Furthermore, cooperation among agent of change

including government, industry, expert, and academician has to be done in order to support sustainable city through developing sustainable public transportation systems.

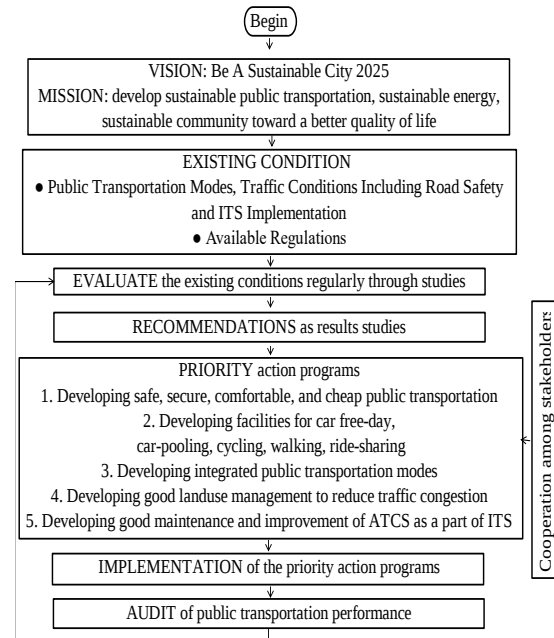


Fig.7 Steps of priority action programs of sustainable public transportation in developing a sustainable city

7. ACKNOWLEDGMENTS

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