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Measurement of People Mobility as Indicator of Sustainable Urban Structure

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ABSTRACT

Transportation problem, which has emerged since the industrial revolution, were found almost in all cities of the world. This problem is characterized by the phenomenon of transport congestion, environmental pollution, accidents, and land use conversion. Some policies and solutions on the transportation problems have been planned and implemented, such as by emission rate regulation, minimal passenger rule, road pricing, new tolroad building, mass transportation. As in Surabaya, some solutions to solve problem of transportation have been made with the aim to solve the traffic jam, such as the planning for river transportation, busway, commuter train, and development of road capacity. At the theoretical level, the pressure of transportation problem on urban environmental arouse attention to the research, or development of a sustainable transport model and extended by considering the urban structure as a factor that affects movement behavior. Since the 1950s several research and theory, was developed to discuss the relationship between urban form and structure and transportation by using correlation models. As one of important variable in research and transportation planning, travel behavior often becomes research topic especially related to the causal researches that explore factors influencing the travel behavior. Travel behavior becomes one of important indicator in determining social economic level of society and characteristic of region or city. This paper aims to identify patterns of people travel behavior Surabaya city and measure the level of sustainability Three steps of analysis that will be conducted in this paper are: identifying travel behavior of Surabaya City, exploring sustainable norm criteria, and measuring travel behavior characteristic by using sustainable criteria.
KEYWORDS: mobility, sustainable and urban structure.

INTRODUCTION

Industrial revolution and world economic development result in human dependency on motor vehicle as parts of their life is increasingly high. The phenomenon is characterized by the growing demand on world fuel and the increasing fuel consumption in the sector of transportation [1]. The highly growing demand of energy (mainly unrenewable resources) causes the world encounters limited available energy. The situation impacts on scarce energy in some areas in the world, ultimately causing the price of the fuel energy increase. This is also faced by Indonesia, a country which previously has surplus of fuel but nowadays it gets deficit.

In the other side, transportation development also suppresses urban condition in Asia and either in Indonesia with the problems of traffic jam, environment pollution, accident, land conversion, etc. Some studies in Osaka, Kyoto, Beijing, Shanghai, Hanoi, Ho Chi Minh, Bangkok, Manila and Jakarta have showed the high impact of transportation on the environment pollution that continuously increase in last four decades [2].

The change of people travel behavior pattern is also identified in big cities in the world such as the increasing people peak traffic in the morning, day or night, people travel is dominated from outskirts of city and other city, traffic volume and non working travel purpose increase [3]. As one of important variable in research and transportation planning, travel behavior often becomes research topic especially related to the causal researches that explore factors influencing the travel behavior. Travel behavior becomes one of the most important indicator in determining social economic level of society and characteristic of region or city [1], [4], [5].

Based on the above considerations, this paper attempts to answer the question: " How is the characteristic patterns of population movement behavior of Surabaya?", and how the level of sustainability of the city of Surabaya as measured from the movement of population mobility behavior?

METHODS

In the aspect of transportation, concept of sustainability has been discussed intensively since 1980s, the following sustainable development concept has become the great attention in the sector of government, private, NGO,

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and international institution. Some definitions and sustainable transportation models are summarized in the following table no 1.[6].

Sustainable transportation model basically develops balancing between supply and demand that integrated in the developing limited resources, and will produce sustainable mobility [7]. Accessibility is influenced by performance of transportation system, land management, people characteristic and quality of service provided in the transportation system. The importance of accessibility concept can be seen from its application as performance indicator in the transportation sector, also since 1960s it has been used for the aspect of economy, social and city [9].

In the same time, development of accessibility needs other resource input, as natural resources (in the form of energy or fuel, land, air etc.), social resources (in the form institution and bureaucracy of mobility and accessibility system), and artificial resources (in the form of tool and equipment and motor cycle). From the above statement, it can be seen that sustainable mobility should be able to manage the development of accessibility and man-made resources (natural, human, artificial) in balance.

The easiest indicator for measuring the usage of sustainable resources is by using resources consumption level or specifically, in the transportation sector, measuring how much oil consumed [7]. In the transportation sector, fuel consumption is much influenced by travel behavior, including mode used, travel distance, travel frequency and other indirect influencing factor (individual economy and social background).

In the determination of indicator, Hasse and Kornbluh formulate accessibility indicator of walking, cycling and motor cycle based on normal distance reached in 10, 20 and more than 20 minutes. Traveling time and distance are based on the average speed of walking 3.2 km/hour, speed of cycling 8 km/hour, and speed of motor cycle 35 km/hour [10].

Table 1. Accessibility Categories Based On Mode of Travel and Distance

Mode of Travel	Ideal	Easy	Moderate	Poor
Walking	• 0-5 minutes • 0-380 meter • ideally accessible pedestrian	• 6-10 minutes • 381-760 meter • easily accessible pedestrian	• 11-20 minutes • 761-1520 meter • moderately accessible pedestrian	• > 20 minutes • > 1520 meter • poorly accessible pedestrian
Bicycle	• 0-5 minutes • 0-760 meter • ideally accessible bicycle	• 6-10 minutes • 761-1520 meter • easily accessible bicycle •	• 11-20 minutes • 1521-3040 meter • moderately accessible bicycle •	• > 20 minutes • > 3.040 meter • poorly accessible bicycle
Automobile	• 0-5 minutes • 0-3.040 meter • ideally accessible automobile	• 6-10 minutes • 3.041-6.080 meter • easily accessible automobile	• 11-20 minutes • 6.081-12.160 meter • moderately accessible automobile	• > 20 minutes • > 12.160 meter • poorly accessible automobile

Based on the above accessibility category, compactness level category is also developed based on distance mean from home to service centers.

Table 2. Compatcness level category based on accessibility to services centers.

Level	Criteria	Region characteristic
A	Average distance to service center = 0 -760	Walking Smart Growth
B	Average distance to service center = 761-1520 m	Bicycle Smart Growth
C	Average distance to service center = 1.521-3.040 m	Suburban sprawl
D	Average distance to service center = 3.041-6080 m	Rural sprawl
E	Average distance to service center > 6080 m	Excessive sprawl

Core based analysis in this paper is evaluation. Theoretically, evaluation can be categorized into three features (1) historical evaluation, that is comparison between before – after, or (2) normative evaluation, that is comparison between fact – norm' and (3) experimental evaluation, that is comparison between without–with [11]. Based on the research features and main goal, analysis in this stage is categorized as normative evaluation that comparing between fact, condition of current travel behavior, and norm, sustainable criteria. Therefore, three groups of analysis that will be conducted in this paper are:

- Descriptive analysis, aiming to identify travel behavior of Surabaya City. Because result of the descriptive analysis will be used as input for further analysis (evaluative and correlation analysis), thus travel behavior will quantified into ordinal scale data, both interval and ratio.
- Theoretical exploration, aiming to get sustainable or norm criteria for the research
- Evaluative, measuring travel behavior characteristic by using sustainable criteria

This paper is part of the main research aims at exploring relationship between urban structure and people travel behavior. As analysis unit on the main research is urban scale or part of the urban or sub district, and people travel behavior constitute an individual behavior pattern, thus transformation or aggregation from individual analysis into urban or part of the urban are needed [12].

Quantitative method is the most dominant approach in describing, explaining and predicting movement pattern and its impact. Analysis of determination level of travel behavior criteria will use criteria from Hasse and Kornbluh in the table 1 above as reference. Although Hasse and Kornbluh explicitly more emphasize on indicator of travel accessibility including dimension of distance and time, yet with the criteria of travel mode, indicator of accessibility from Hasse and Kornbluh indirectly contain 'value' of mobility. Based on the analysis of energy needs and travel cost from each mode, the result can be drawn from the most efficient to the most extravagant those are walking, cycling, motor cycle, public transportation and four wheel vehicle. The following is diagram taken from developing criteria from Hasse and Kornbluh.

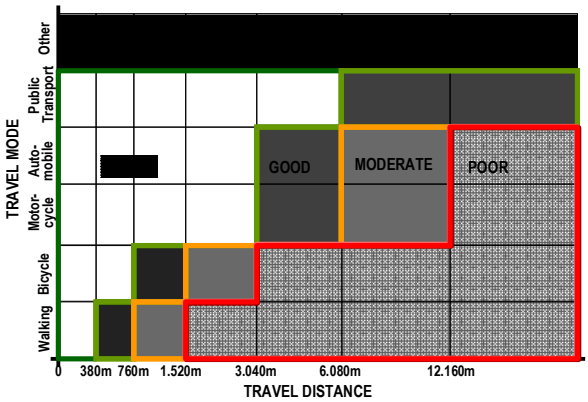

Fig.1. Matrix of continuous mobility indicator
(Sources: Researchers summary 2010, Hasse and Kornbluh 2004)

Beside measurement of mobility level, the existing travel pattern can also be used as indicator of compactness level or 'sprawl' of a region. Table 2 above classify compactness level of a region into five categories, those are walking oriented region (walking smart growth), non motor cycle oriented (bicycle smart growth), suburban sprawl, rural sprawl, and excessive sprawl. The five categories can also be grouped into three categories those are: (i) smart growth (radius from service center below 1520 meter), (ii) sprawl (radius from service center of 1521-6000 meter) and (iii) excessive sprawl (radius from service center above 6080 meter). The use of three axes matrix below illustrates the existing indicator in the next analysis.

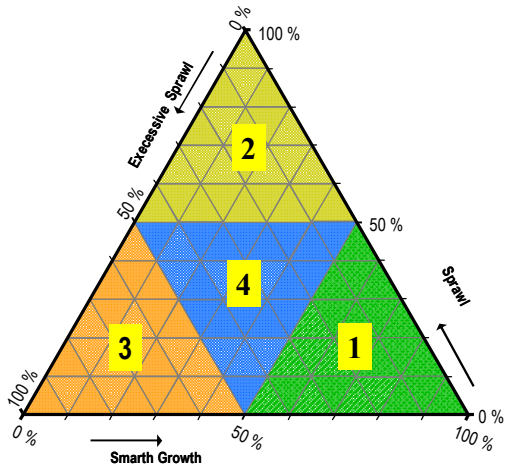

Fig.2. Three axes matrix of region compaction level indicator.
(Source: Researchers summary 2010)

RESULTS AND DISCUSSION

Measurement of sustainability level of travel is using mobility indicator containing distance, time and energy or travel efficiency. Therefore, value of indicator is gotten by using mobility level based on table 1 and diagram 5 above (sustainable mobility indicator matrix). Based on table 2 and diagram 6, mobility is categorized into four categories those are ideal, good, fair, and bad categories. Beside matrix of mobility indicator, measurement of sustainable travel behavior also indicates compactness level or sprawl of region. The usage of table 3 and diagram 4 will result in conclusion about region compactness level categorized into smart growth (radius from service center below 1520 meter, sprawl (radius from service center between 1521-6080 meter) and excessive sprawl (radius from service center above 6080 meter).

In the measurement of mobility level, shown in table 3 and picture 7 below, can be drawn conclusion as follow:

- About 43,41% of people travel in Surabaya have ideal level of people travel mobility. From 33.73% of ideal travel, 6,59% uses public transportation, 3,51% uses walking, 2,23% uses bicycle, 28,77% uses motor cycle mode and 2,31% uses four wheels vehicle. Travel mobility with good category is 21,66% with description of 4,28% walking, 1,97% bicycle, 10,79% motor cycle and the rest 2,49% uses four wheels vehicle. Level of people travel mobility with moderate category is 16,01% from all travel with description of 2,05% walking, 1,37% with bicycle mode, 9,93% motor cycle and 2,66% four wheels vehicle. Poor mobility level has value of 18,92% with description of 2,31% walking, motor cycle 12,33% and four wheel cycle 3,77%.

- Table 3. Frequency distribution of people travel mobility level (travel distance based on mode)

Travel Mode	Travel Distance							
	< 380 m	381-760 m	761 - 1.520 m	1.521 - 3.040 m	3.041 - 6.080 m	6.081-12.160 m	> 12.160 m	Total
Walking	4,22%	2,41%	0,60%	0,60%	0,60%	-	1,20%	9,64%
Bicycle	1,81%	-	1,81%	1,81%	-	-	-	5,42%
Public Transp.	-	-	-	-	0,60%	1,20%	-	1,81%
Motorcycle	1,81%	-	3,61%	15,06%	10,84%	6,02%	6,63%	43,98%
Automobile	-	-	-	6,63%	9,64%	10,84%	9,04%	36,14%
Other	-	-	-	-	0,60%	0,60%	1,81%	3,01%
Total	7,83%	2,41%	6,02%	24,10%	22,29%	18,67%	18,67%	100%

- In line with each characteristic of travel mode, category of short travel (below 1520 meter) dominated by non-motor cycle mode and walking. For middle category (between 1521-6080 meter) dominated by motor cycle, while category above 6081 meter is dominated by four wheel vehicle. As a whole, motor cycle mode constitute the most mode used. The phenomenon generate discussion about research or transportation planning about the strength and weaknesses of motor cycle mode. In one side, motor cycle mode is dominating the transportation mode in big cities in Indonesia, it has price that can be afforded by most people. In the other side, motor cycle mode has negative characteristic, such as the highest violator of traffic rule, the biggest part of traffic accident, the most difficult to lead, it start to be used as the farthest travel mode (working and going to the original village), struggle with public transportation.

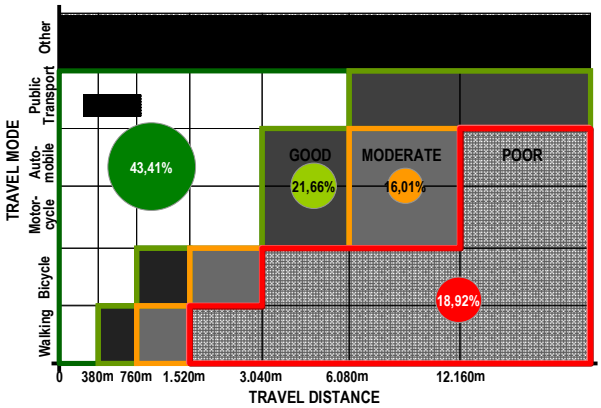

Fig.3. Frequency distribution of people travel mobility level

Detail conclusion shown in picture 8 and picture 9 below are about behavior of travel distance in sub district:

- Among 31 sub districts as a sample, Genteng sub district is a region with the best compactness level or service center distribution is relative near, and Pakal and Bulak sub district is the worst compactness level. This is indicated with the frequency of travel distance below radius of 1520 in Genteng sub district with relative high about 62% compared with Gununganyar sub district with only 0,1%.

- In the category of travel distance out of 6081 meter (Excessive sprawl), the biggest frequency is in Bulak, Pakal and Lakarsantri sub district, followed by Sambikerep and Tandes

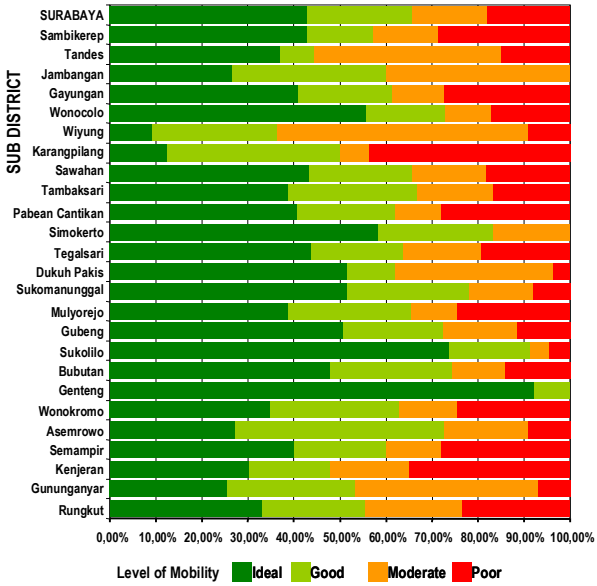

Fig. 4. Level of mobility based on sub district

The above description will be more illustrated in the picture below showing that Genteng sub district is a region that has good compactness and travel distance level. Kenjeran sub district is dominated by travel with travel distance below 1.6 km (smart growth). Sukolilo and wonocolo sub districts have similar typology, dominated by middle distance travel distance (between 1.6-6 km) with the amount of 40-60%, followed by travel above 6 km with amount of 20-40%, and short distance (below 1.6 km) only 10-20%. The third typology is Gununganyar sub district and Semolowaru with (50-70%) dominated by travel distance above 6 km.

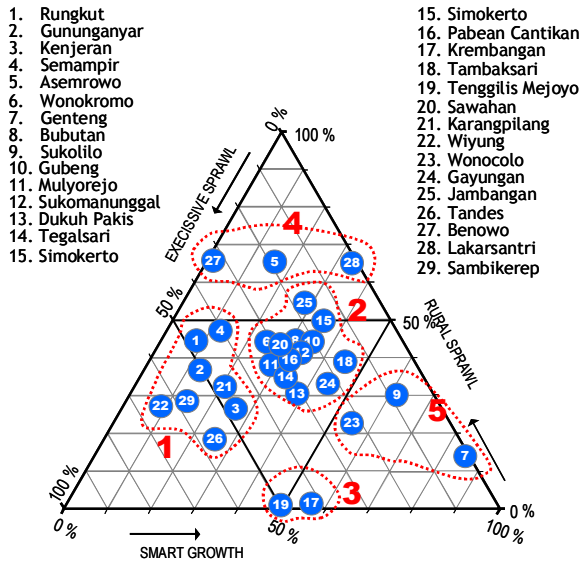

Fig.5. Travel distance based on sub districtReferences

Conclusion

Based on the findings described in the previous section, associated with the aim of research can be concluded matters as follows:

- Mobility is one indicator of the sustainable travel behavior, which combines the criteria of accessibility and energy use. Sustainable mobility balance sheet can be formulated in the function higher accessibility and lower transport consumption

- Motorcycles dominate mode of transportation in Surabaya (43,98%), both in the category of short(below 1520 meter) -and medium(between 1521-6080 meter)-range distances.
- Most of the mobility of the population (43,41%) n the city of Surabaya can be categorized as an ideal.. From 43,41% of ideal travel, 6,59% uses public transportation, 3,51% uses walking, 2,23% uses bicycle, 28,77% uses motor cycle mode and 2,31% uses four wheels vehicle

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