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Pedestrian Behavior in Various Types of Settlement in Yogyakarta City

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Abstract: Walking is recognized as one of the best ways to actualize sustainable transportation. Additionally, built environment is also considered as factor that affects travel behavior, thus this study aims to assess the effect of built environment conditions on travel behavior of the pedestrian. The study was conducted by qualitative-quantitative method with the data collection using questionnaires through simple random sampling. Yogyakarta as one of the strategic cities in Indonesia was chosen to measure the influence of the built environment on travel behavior since Yogyakarta also has various types of settlement. According to the results, the built environment does not straightly influence pedestrian behavior, except the density and diversity of land use yet in very low relation. However, this study found that there is a potential of homogeneous settlement to generate more walking trips if it is combined with the uniqueness of facility in Indonesia like moving trader.

Keywords: travel behavior, pedestrian, built environment, urban settlement, sustainable transportation

1. INTRODUCTION

A city is a very complex unit of life. It consists of solid, void and linkage components that are interrelated then it can form the city dynamics (Kristiadi, 2014). As time goes by, a city grows larger and becomes harder to be controlled. According to UN-Habitat (2016), the population living in urban areas increases every year. Based on the data of UN-Habitat (2016), in 1990 there were 43% or 2.3 million of the world's population lived in urban areas and in 2015 the number increased to 54% or around 4 million residents. The condition can affect the built environment condition especially in building and population density in urban areas. UN-Habitat (2016) also stated that there is no region experiencing a decline in population. Therefore, all of the cities in the world, including Indonesia, must be able to anticipate the bad impacts of urban growth so that development in the city can run sustainably (sustainable development).

Sustainable transportation is one of the essential goals to achieve sustainable development since transportation is a derivate demand of human daily activities that meet the needs of residents. According to Srinivasan (2004), basically the population firstly decided the pattern of daily activities and thus a travel pattern that relates to travel behavior will be formed. Both people who live in urban or rural areas need to travel around their place to fulfill their daily needs. If the area around one's residence is unable to meet the needs, then the residents will travel out of their residential area. Built environment factors in a residential area can influence the travel behavior of residents. High density of settlements, diverse land uses and good accessibility can shorten travel distance and encourage the use of environmentally friendly modes of transportation e.g walking (Talen, 2009).

In the past, there were not too many choices of transportation vehicles. Mostly the activities were undertaken by walking or using a horse and bicycle. By contrast, in this era, especially in Indonesia, there are not too many people walking around to fulfill their needs. There are various transportation modes from the traditional to the sophisticated one along with the development of the infrastructure so people can move faster from the origin to destination. On the other side, it also increases the production of carbon that will decrease the quality of the environment in the city.

Leskovec and Delp (2017) found that the Indonesian walking habit is below the global standard. Indonesian only walk 3,513 steps per day meanwhile the minimum steps per day is 5,000 steps per day. It shows that Indonesia has a very terrible habit of walking compared with other countries around the world. It is shown by the red color on the map below. In the level of Asia, Hong Kong is on the top level in walking habit namely 6,880 steps daily, followed by China with 6,180 steps per day (Leskovec and Delp, 2017)

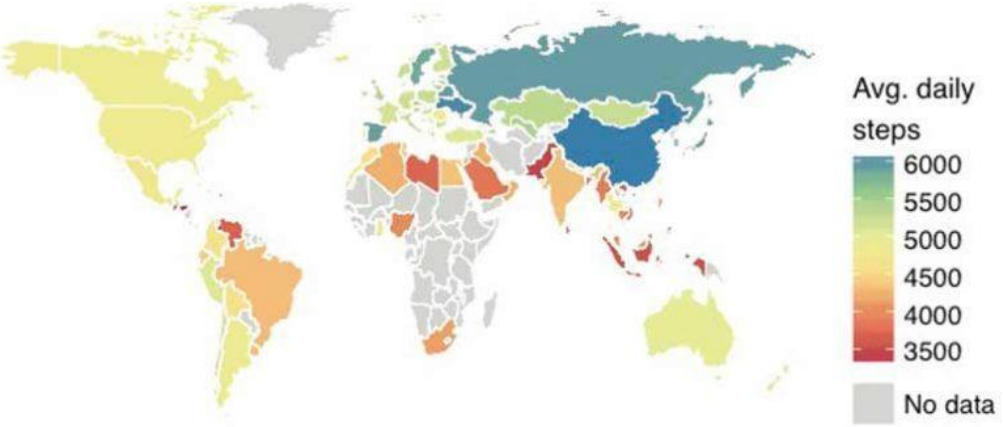

Figure 1 Average daily steps of people based on the country in the world
Source: Leskovec and Delp, 2017

The city of Yogyakarta is well-known as an education city in Indonesia, especially for higher education. The city has a medium size but it has a high spatial hierarchy and rapid growth that attract researcher to conduct research in Yogyakarta. The physical condition of settlements in the city of Yogyakarta is quite diverse and also has a form of Indonesian traditional settlement, namely urban kampong (Heryati, 2008). The condition that urban kampong is located around the city center, having a high level of density, diverse land uses, and interconnected regional designs should be able to generate more sustainable travels. The conditions of urban kampong as a traditional settlement are different from the formalist and modernist settlement which have just developed in Indonesia where it tends to have a homogeneous impression, less connected design and accessibility since its development leads to the suburbs.

Differences in built environment factors in urban settlements can also lead to different travel behavior. Ewing and Cervero (2010) stated that settlement form that can be seen from built environmental factors such as density, land use diversity, accessibility, design and distance to transit facilities have an influence on travel behavior. In more detail, Talen (2009) stated that dense settlements with mixed land use will increase proximity so that travel can be reached only on foot. However, despite having a mixed, dense, accessible settlement, the use of private vehicles in the city of Yogyakarta is still relatively high and grows every year.

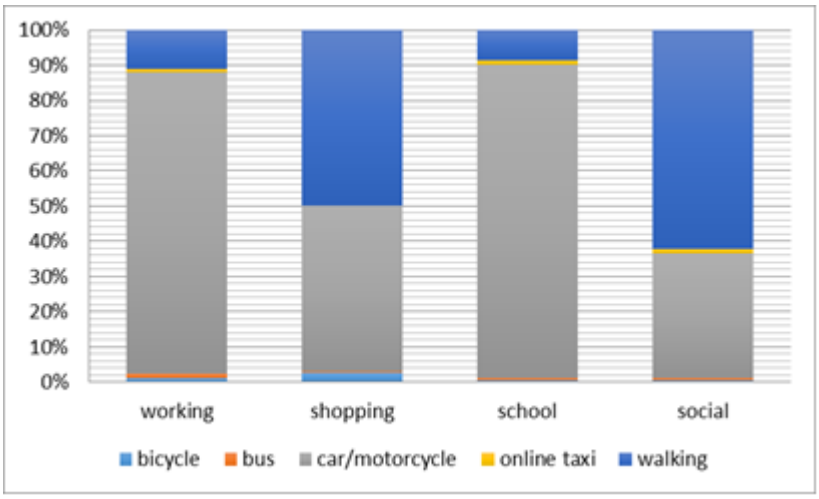

Figure 2. Mode choice of Yogyakarta residents
Source: Dewi, 2018

Dewi (2018) found that most of the trips in Yogyakarta that are undertaken by private vehicle, mainly on routine trips (e.g working and education trip). Trips that are undertaken by walking are only for social activity (47,45%) and shopping (43,16%). In other words, walking is usually undertaken regarding to non-routine trips. These data show that the use of private vehicle is still massive in Yogyakarta, supported by the data from DIY Transportation Department in Wardhani (2018) that stated the number of motorized vehicles, especially motorcycle in the city of Yogyakarta increased by 211% in the 2016-2017 period. Dewi (2018) also found that the built environment is not significantly influencing travel behavior. Therefore, this study aims to identify the influence of built environment conditions more specifically on travel behavior of pedestrian. Could the built environment reduce the travel distance as well as increasing the number of pedestrian trips?

2. BACKGROUND

2.1 Travel Behavior Assessment

According to Dimitriou (1992), travel behavior is the first step of urban transportation modeling. Sya'bani (2016) stated that travel behavior is affected by the individual effort to complete their needs. Furthermore, according to Stageby (2000), travel behavior provides information about travel frequency; traveling time and travel distance; mode choice; travel purpose; and travel distribution.

a. Travel frequency is associated with trip intensity from the origin to destination.
b. Travel time and travel distance are associated with the length of the way that is crossed and the time that is spent to move from the origin until arriving at the destination.
c. Mode choice is about the type of vehicle that is used to move from the origin to destination.
d. Travel purpose explains about the destination of trips e.g shopping, working, school, and social purpose.
e. Travel distribution is about the travels' direction in the scope of spatial and time.

2.3 Defining Urban Settlement

Dobbins (2009) groups the settlement into three groups namely traditional, formalist and modernist. The traditional settlement is defined as an organic development that is derived from an interactive relationship between people and local natural forces in shaping urban places. The communities mostly arrange their neighborhood according to natural system namely watercourses, land contours, arable soils, orientation and climate (Dobbins, 2009). The houses and shops with various forms, shape the street and it connects to each other. The formalist is easily looked from the street pattern which uses geometric order and the modernist as a conscious and radical break

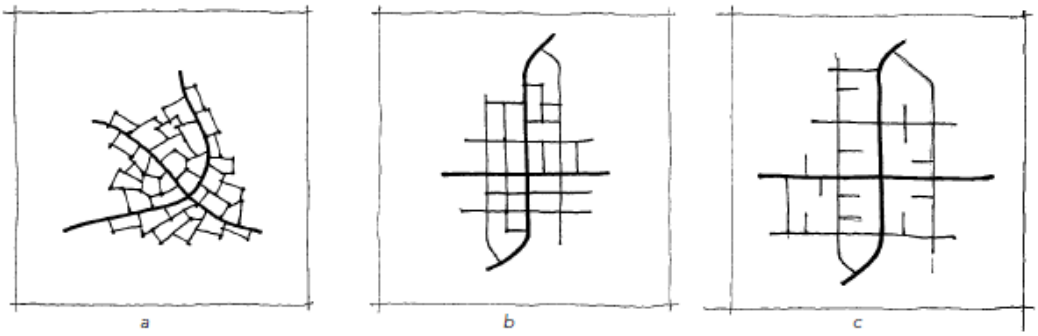

Figure 3. Type of settlements (traditional, formalist, modernist)
Source: Dobbins, 2009

In the case of Indonesia, there are also some kind of traditional settlements named kampong or "kampung" in Bahasa Indonesia (Heriyati, 2008). This settlement is identified as mix and dense of land use with the organic configuration of the street. However, there is also the other kind of settlement which rapidly grows in the suburbs namely formal housing. This settlement is identified with a homogenous of land use, less dense, and unconnected street pattern. In addition, in this study, the term of kampong will represent the traditional settlement, and formal housing (residence) will represent the formalist and modernist settlement.

3. METHOD

3.1 Data Collection

The data is collected using questionnaires that are spread randomly in the study area. The case study is chosen by considering some criterion based on the previous theories about the built environment such as density and diversity of land use, destination accessibility, and design. Moreover, the data for the travel behavior of people who live in each type of settlement (i.e traditional, formalist, modernist) is gathered using questionnaires. The respondents are chosen through a simple random sampling method. There are 150 respondents that are chosen with each settlement contains 50 respondents. The criterion to choose the case studies are shown by the table below.

Table 1. Criterion in choosing the case study

Location	Distribution	Proximity to activity center	Building density	Street pattern
Kricak Kidul Kampong	Northside	Far away from CBD and government center	Moderate	Organic
Tukangan Kampong	Middle side	Near the CBD	High	Organic
Puri Timoho Asri Residence	Northside	Near the government center	Moderate	Cul-de-sac
Green House Residence	Southside	Far away from CBD and government center	High	Grid

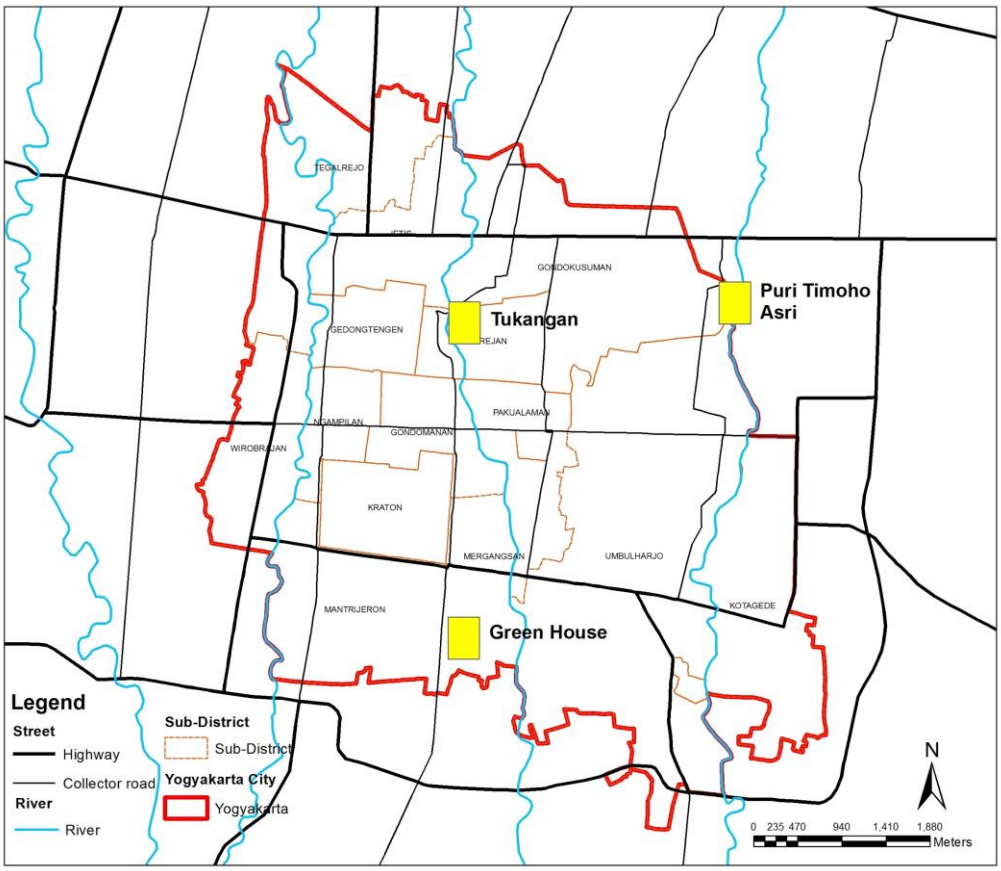

Figure 4. Location of case study
Source: Author, 2018

3.2 Data Analysis

The result of the questionnaires was analyzed qualitatively by comparing travel behavior in

each type of settlement. Then, the relation between the built environment (independent variable) and travel behavior (dependent variable) was analyzed quantitatively using a chi-square analysis. The calculation of chi-square analysis is undertaken using statistics software—SPSS Statistics.

This study also uses hypothesizes, namely:

a. Null hypothesis: There is no difference between the dependent variable with the independent variable of urban kampong residents and formal housing residents.
b. Alternative hypothesis: There is some difference between the dependent variable with the independent variable of urban kampong residents and formal housing residents.

In addition, built environment assessment uses a scoring method based on the theories and standards. The unit of built environment assessment is in the scope of the area. The score is given to each area (each case study) which is delineated with 100 meters of the radius.

a. Mix Land Uses analyzed using entropy index with the formula:

$$\textit{Land-use mix} = \frac{(-1)*[\left(\frac{b1}{a}\right)ln\left(\frac{b1}{a}\right)+\left(\frac{b2}{a}\right)ln\left(\frac{b2}{a}\right)+\left(\frac{b3}{a}\right)ln\left(\frac{b3}{a}\right)+\cdots]}{ln(n)}$$

b. Building density is analyzed using Building Coverage Ratio (BCR) with the formula:

$$\text{BCR} = \frac{Built\ area}{Total\ area}$$

c. Scoring analysis to know the rate of facilities affordability by considering the National Indonesian Standard (SNI).

4. RESULT

4.1 Built Environment Condition

4.1.1 Density and diversity of land use

A. Density

Density is measured by combining the population density and building density then compared with the standard. Population density states the number of residents living in a certain area (people/hectare). Based on the standard of the Indonesian Central Statistics Agency, the ideal standard of population density is 96 people/hectare. On the other side, building density is measured by BCR (Built Coverage Ratio) that compares the area of built-up area and the total area of its land. According to the General Director of Ciptakarya (2006), the standard of building density classified as: BCR above 70% is in the high category, while 50% -70% is in the medium category.

If the ideal standard of population density is 96 people/hectare and building density is 70%, then the ideal score for settlements is 67.2. Therefore, if the score of more than 67.2 is classified as high and if it is less than 67.2 it is classified as low. Tukangan becomes a settlement with highest density with the score of 202.40 then Green House with 71.74 and Timoho Asri with 52.35.

B. Diversity of Land Use

The diversity (mixed) of land use shows the variation in the use of space within an observation area. Land use assessment in this study uses entropy index to see the balance level of land use within an area. The data is gathered by field observation in the case study then it is mapped by GIS. The conditions of land use in the case study are shown below.

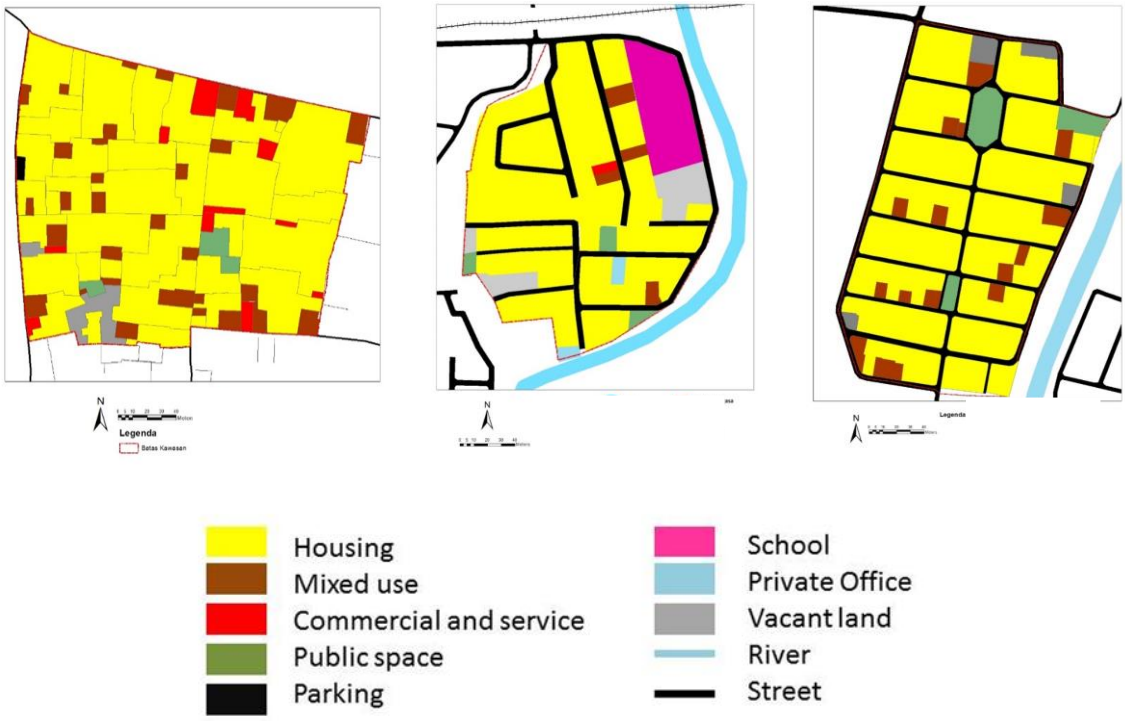

Figure 5. Land use of the case study (Tukangan, Timoho Asri, Green House)
Source: Author, 2018

Based on the maps, it can be seen that the main function of each area is housing. There are supporting functions in the form of commercial and service, public space, office, and mixed use. The mixed-use in the urban kampong (traditional settlement) is mostly a mixture of a house with commercial or service, while in the formalist and modernist settlement is a house with an office.

The calculation of the entropy index found that the index value of each case study is almost the same, which is equally low. The level of diversity of land use will be better if the value is close to 1. According to the analysis, the entropy index in Green House is highest and Timoho Asri is lowest.

C. Analysis of Density and Diversity

According to the analysis of standards, the score of ideal density is 67.2 and the minimum level of balance of entropy index stated as at least 0.5. Therefore, the minimum score for ideal density and diversity should be 33.6. In addition, Tukangan becomes the most ideal area among all the case study with more details are as follows.

Table 2. Density and Diversity Assessment

Variable	Case Study		
	Tukangan	Green House	Timoho Asri
Density			
Building density	76.38%	62.39%	45.53%
Population density	265	115	115
Diversity of Land Use			
Entropy index	0.22	0.23	0.2
Total Score	**44.52**	**16.50**	**10.47**

4.1.2 Destination accessibility

Destination accessibility also can be seen as access to facility. Access to facility is measured based on the average distance from one area to the nearest facility. The facilities that are considered in this study namely commercial, school, and public space according to the variable of the trip purpose. The distance to the city center is also considered since more facilities are located in the city center.

Based on the distance analysis, it is found that Tukangan Kampong has highest level of accessibility. Tukangan Kampong has highest level of accessibility because the distance is very close to the city center, hence it is really easy to access various facilities. On the other side, Green House Residence and Puri Timoho Asri Residence that is located on the border of Yogyakarta, makes the level of accessibility is quite low. However, when it is analyzed from the affordability, all of the case studies are affordable by facilities, especially schools, and commercial, as shown by the following maps

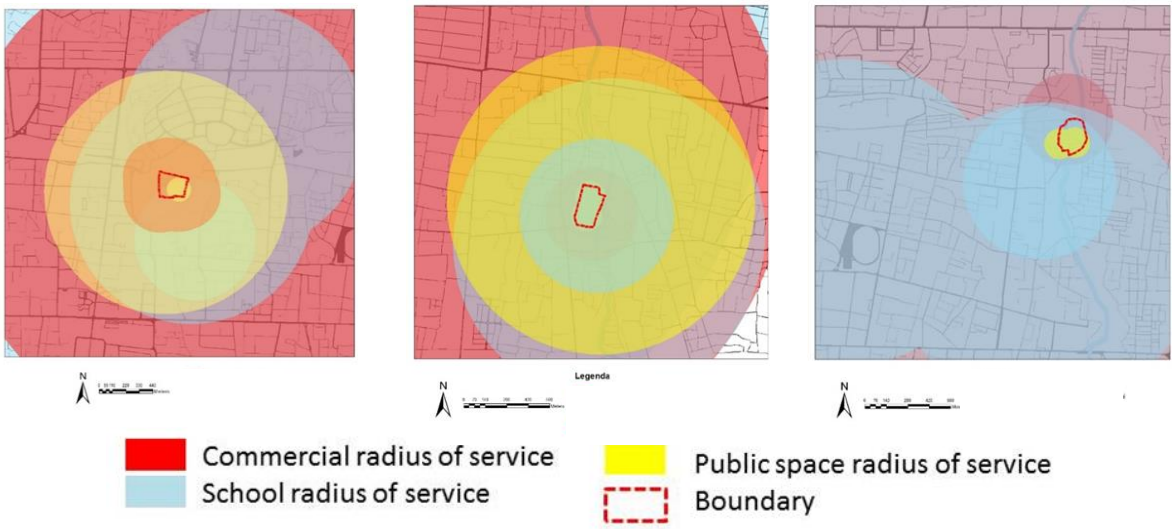

Figure 6. Facilities coverage at each type of settlement
Source: Author, 2018

The final accessibility analysis is undertaken by comparing the distance to the nearest

facility with the SNI standard and then multiplied by the number of facilities available as in the table below. If the analysis of accessibility combines distance with the density of facility, the results are slightly the same. Tukangan is surrounded by many facilities both within and outside the kampong. However, Green House Residence and Puri Timoho Asri Residence have much lower accessibility score. It is happening because there are very few facilities within the proximity of these settlements.

Table 3. Accessibility Assessment

Facility	Case Study		
	Tukangan Kampong	Green House Residence	Puri Timoho Asri Residence
Commercial	26	15.06	15
School	27	30	21.4
Public space	30	30	7.5
City center	23.33	14.72	18.62
Total Score	**106.33**	**89.78**	**62.52**

Accessibility assessment is undertaken by scoring the accessibility variables to facilities and distance to the city center. The distance and density of facility are compared with the SNI standard to see its adequacy, then multiplied by the maximum value on each variable which is 30. Based on the results of the analysis, the maximum score is 120, so the classification of categories is divided into three, namely 0-40 (bad), 41-80 (moderate), and 81-120 (good). Therefore, based on the table, Tukangan Kampong and Green House Housing get good scores, while Puri Timoho Asri Housing gets a moderate score.

4.1.3 Design

The variables of design mostly describe street conditions. The sub-variables of design are street pattern, block size, shade level of the street, and physical edge. A street pattern is a configuration form of a crossroads component. Assessment of road patterns is undertaken by nodegram Marshall (2005), which compares the ratio of three intersections (T-junctions) with four intersections (X-junctions) and the ratio of cul de sac to cells. The street pattern are categorized into type A, B, C, D which has various level of connectivity. This study also considers the existence of the physical edge that can bother the trip and thus, an area without any physical edge would be better. The other criterion are shown below.

Table 4. Design criterion

Criteria	Standard
Street pattern	The type of A, B, C, D
Block size	600 meters of circumference
Shade level of street	75% of street are shaded
Physical Edge	The existence of physical edge (portal, high wall, high fence)

The site design analysis is undertaken to assess the overall quality of design that can support the actualization of sustainable transportation. The analysis is undertaken by scoring on each sub-variable then added up. The higher the score, the better. Tukangan gets highest score of design which means Tukangan has a good level of design. By contrast, Puri Timoho Asri has the worst level design compared with the others. The more details are shown in the following table.

Table 5. Neighborhood Design Assessment

Criteria	Tukangan	Score	Green House	Score	Puri Timoho Asri	Score
Street pattern	A	50	B	100	D	10
Block size	Less than 600m	100	Less than 600m	100	More than 600m	50
Shade level of street	66% shaded	66	64% shaded	64	22% shaded	22
Physical Edge	No	100	Yes	50	Yes	50
Total Score	**316**		**314**		**106**	

4.2 Travel Behavior

The mode choice is related to the type of vehicle used to travel. The modes of transportation in the study are varied namely bicycle, bus, car/motorcycle, online taxi as well as walking. Based on the results of the analysis, there is a tendency of mode choices of transportation in Yogyakarta that still depend on private vehicles. The use of private vehicle is quite high in Yogyakarta, especially for routine trips. People usually go to work and go to school by car or motorcycle. By contrast, the use of private vehicles and walking for shopping and social purpose is almost balance, even higher than the private vehicle itself. Therefore, the pedestrian activities are mostly shown in shopping and social trips.

4.2.2 Working trip

Working is categorized as a routine trip since this activity is undertaken frequently (normally 5 days per week). However, based on the data, working trip is only undertaken by people who live in traditional settlement (kampong with a very small number). These 11 of working trips are traveled in an average distance of 786.36 meters. The distance is above the walking distance standard, which means people must put more effort to arrive in the workplace.

Table 6. Travel behavior in working trip

Variable	Working trip		
	Tukangan	Green House	Puri Timoho Asri
Number of trip	11	0	0
Frequency	5.72	0	0
Distance	786.36	0	0

4.2.3 Shopping trip

Shopping can be categorized as semi-frequent trips since it is usually executed around 4 days per week. People who live in Puri Timoho Asri travel a very short distance for shopping, but the number of the trip that is generated by this settlement is also lowest one. It can indicate that they are well-facilitated but there are only few people want to walk. By contrast, Tukangan generates more people to walk for shopping along with the longest distance that is

taken. It can indicate that people who live in the traditional settlement have higher willingness to walk than the other settlement.

Table 7. Travel behavior in shopping trip

Variable	Shopping trip		
	Tukangan	Green House	Puri Timoho Asri
Number of trip	61	41	16
Frequency	4.85	4.48	4.5
Distance	213.61	117.56	10.00

4.2.4 Education trip

Education also becomes a part of a routine trip. Mostly this trip is carried out by children. According to the data, there are only few people walking to school. People who live in Tukangan, travel an average of 920 meters, while Green House just travel 115 meters with the zero results for Puri Tiimoho Asri.

Table 8. Travel behavior in education trip

Variable	Education trip		
	Tukangan	Green House	Puri Timoho Asri
Number of trip	5	3	0
Frequency	3	5.4	0
Distance	920	115	0

4.2.4 Social trip

The social trip is a unique travel purpose because it embraces many activities namely religious activity, sport, vacation and so forth. Tukangan generates more social trips than others but the average of distance is also highest. Green House also generates many social trips in short distance. It is suspected because Green House has good social facilities in its areas such as mosque, tennis field, and badminton field.

Table 9. Travel behavior in Social trip

Variable	Social trip		
	Tukangan	Green House	Puri Timoho Asri
Number of trip	57	55	10
Frequency	3.5	4	4.5
Distance	336.67	120.55	157

4.3 Travel Behavior and Built Environment

4.3.1 Travel distance

Relation analysis between the built environment and travel distance uses cross-tabulation analysis. The result shows that only the p-value of density and diversity that are less than α (p-value < α). It means that only density and diversity of land use that influence the travel

distance. On the other hand, the Somers' d coefficient (C) shows a very low connection. The value of Somers' d coefficient is only 0.151 which is less than 0.199 so the connection is not too significant. The more details are shown by the table below.

Table 10. The relation between built environment and travel distance

Variables	α	Travel distance	
		p-value	C
Density and Diversity	0.1	0.001	0.151
Design		0.278	0
Destination accessibility		0.278	0

4.3.2 Travel frequency

This analysis of the relation between the built environment and travel frequency uses the same method with the previous analysis for the travel distance. The result of this analysis shows the same result. There is no relation between design and accessibility since the p-values are greater than α (p-value > α). Density and diversity of land use is the only variable that is related to travel frequency. The better density and diversity, the more frequent the trip is undertaken. Moreover, the Somers' d coefficient is also less than 0.199 which means the density and diversity are not significantly affected to travel frequency as shown in the table below.

Table 11. The relation between built environment and travel frequency

Variables	α	Travel frequency	
		p-value	C
Density and Diversity	0.1	0.002	0.174
Design		0.784	0
Destination accessibility		0.784	0

5. DISCUSSION

The built environment assessment at each type of settlement shows various conditions. Generally, Tukangan as a traditional settlement gets highest score in each variable along with Green House in the second position. Compared with the travel behavior assessment, the result shows that the better condition of the built environment will encourage larger pedestrian. This statement is supported by Talen (2009) that states that settlement with mix and dense and has good accessibility will encourage more trips with environmentally friendly modes of transportation.

Table 12. The score of built environment

Case Study	Density and Diversity	Destination Accessibility	Design	**Total Score**
Tukangan	44.52	106.33	316	466.85
Green House	16.5	89.78	314	420.28
Puri Timoho Asri	10.47	62.52	106	178.99

Chi-square analysis shows that there is almost no relation between built environment condition and travel behavior. The better condition of the built environment does not straightly influence travel behavior. Tukangan which has a better condition in the built environment, the travel distance is also highest. It can be affected by the willingness to walk of each person. People who live in traditional settlements walk frequently and even farther so

that it can indicate that the environment is quite comfortable for the pedestrian. The design of the neighborhood that is more connected, shaded, and accessible makes the pedestrian activity is more vivacious in the traditional settlement. The connectivity of formalist is better compared with the traditional settlement. The grid pattern is more interconnected so that people can reach one location in a short distance. This statement has also been proven by Marshall (2005) that stated that grid --type B in his street pattern theory has a high level of connectivity.

Table 13. Built Environment and Travel Behavior

Variable	Chi-square analysis	
	Travel distance	Travel frequency
Density and Diversity	Very low	Very low
Design	Not related	Not related
Destination accessibility	Not related	Not related

Moreover, the condition of facilities in Yogyakarta City is also quite unique, especially for shopping facility. Dewi (2018) found that people who live in formal housing can go shopping with a very short distance because there are moving traders or "pedagang keliling" that come to the housing area every morning. Hence people who live in a homogeneous resident can walk shorter than the traditional settlement since the trader comes closer and the customers just need to walk to the front side of their home.

6. CONCLUSION

This study aims to see the relation within travel behavior especially for walking trips and the built environment. The built environment in various settlements of Yogyakarta city has some differences. The traditional settlement or in this study called kampong or "kampung" has excellent scores of the built environment. In other words, the traditional settlement is a type of settlement which can generate more sustainable trips. On the other hand, the score of Green House is usually in between Tukangan and Timoho Asri. It means that though Green House is categorized as formal housing (i.e homogeneous and less accessible) it has potency to generate a lot of walking trips

According to the analysis, it is found that Tukangan generates more walking trips than the others with the frequency is nearly the same with others. However, the distance of trips are quite diverse with the average distance is greater than the others. The analysis shows that the people of Tukangan walk farther than people of Green House and Timoho. However, the relation between the built environment and travel behavior shows that there is no relation between design and accessibility to walking trips and density and diversity of land use is not significantly affecting walking trips. It indicates that there is a better willingness to walk of people who live in a traditional neighborhood. Moreover, there is also a unique factor of how Indonesian sell their product (e.g some traders move closer to the customer) so the trip can be undertaken in a very short distance through the condition of access and diversity of land use is not too good based on the built environment.

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