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Built Environment and Its Impact on Bus User Walking Activities

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ABSTRACT

The pedestrian ways serve as a feeder facility that connects the transit system in transportation, and 88% of Trans Semarang Bus passengers walk from or to bus stops. However, the current pedestrian ways do not meet the needs of pedestrians in the surrounding environment. So it can be seen how the built environment, such as density, diversity, and pedestrian ways design can influence each other on pedestrian conditions in Semarang. The calculation of component density using the Floor Area Ratio (FAR) method shows that most of the areas along the Trans Semarang Bus corridor included in the low-density category with an average building height of 1-2 floors (5-10 meters). Meanwhile, the results of the calculation of the diversity component index used land use for trade and services and education. The design of pedestrian ways as one of the complex components produces the same pattern of conditions throughout the corridor. The closer to the urban center, the pedestrian ways design elements more be complete. The linear regression model provides information on pedestrian intensity with the diversity of components (balancing index). Increasing the balance of land use in an area will increase the potential for pedestrian movement. Also, there are findings of factors that play a role in shaping the regression results and differentiating research results with previous studies. Commercial and educational land use (diversity correlation factor); regulations, urban density, completeness of pedestrian ways (differentiating factors in components); and topography, site range, pedestrian characteristics, season (differentiating factors excluding components).

Keyword : Built Environment, Bus Trans Semarang, Pedestrian Ways.

INTRODUCTION

The development of a transit-based public transportation system is being done intensively in various Asian countries as an alternative in suppressing population growth and private transportation. The Asian region has become the axis of developing an unhealthy transportation system that causes various problems, such as congestion, air pollution, and sprawl problems (Makarova et al., 2017). To overcome this, the World Health Organization (WHO) encourages countries to implement sustainable transportation systems that focus on safe, efficient, accessible, affordable, inclusive, green, and healthy mobility and transportation.

A Transit-Oriented Development (TOD) is a form of sustainable transportation that emphasizes integrating urban spatial design to unite people, activities, buildings, and public spaces through connectivity that can be accessed by walk (ITDP, 2017). Increasing the intensity of walking (walkability) is considered as one of the effective solutions in overcoming unhealthy transportation because it can minimize congestion, increase environmental sustainability, encourage physical activity, improve public health, and improve the appropriateness of urban settlements (Blanco & Alberti, 2009). The pedestrian ways are commonly referred to as a sidewalk in a transit-based transportation system is a facility feeder that connects a transit center in the form of a stop with other activity functions in its surrounding area (Hu et al., 2013). However, the lack of optimal pedestrian ways in several countries is a challenge for the procurement of a sustainable transportation system.

Various studies suggest that the optimization of pedestrian ways such as the completeness of design components, an attractive, safe, and comfortable city shape will increase residents' tendency to walk to a destination (Özbil et al., 2015). Changes in the built environment, such as land-use planning and urban design, are also crucial in increasing pedestrian activity in cities (Timmermans, 2009). Research on the relationship between the conditions of the built environment and the tendency to walk in the public transportation system is still rare. Various parties inclined to be focus on the opportunity to increase procurement of the transportation system without seeing how developments that occur affect the environment. As a result, the development of a new transportation system can be linear with uneven distribution of building density and land use that results in several pedestrian ways, not right functioning.

Developing the built environment in the public transportation system is closely related to countries in the European region. Where is the initial milestone in research on the built environment was first carried out by Cervero and Kockelman (1997), by looking at the context of the built environment in the European region as an agenda to welcome new urbanism concept. In the same source, formulated three main components in assessing the built environment in the form of density, diversity, and design. The density that defined as the component produced by observing population density per household and building density per area. Research on the built environment and pedestrian activity in previous studies found that areas with a high level of density had more influence on the intensity of people walking (Oktaviani et al., 2020). The diversity component that represented as a land-use balance index by comparing the ratio of residential and non-residential (commercial) land use. The higher the level of land use balance in an area will increase pedestrian activity (Sung & Choi, 2013). The design component is one of the components that refer to the assessment of the completeness of the pedestrian ways and its integration with the road network system. In detail, the pedestrian ways design attribute has less effect than the other two variables because it is necessary to relate to the surrounding demographic conditions and land use diversity (Cervero & Kockelman, 1997).

Along with the development of science, assessing the components of the built environment is also increasingly diverse. A study conducted by Duduta (2013), developed indicators for assessing density components in the form of building density measurements, which are related to building height or what is known as the Floor Area Ratio (FAR) analysis method. In the same source, takes a minimum distance of 200 meters from the stop point and divides it into three categories of density level assessment, namely low density (building 1-2 floors), medium density (building 3-8 floors), and high. density (building >8 floors). Simplifying the research of Cervero and Kockelman (1997), the diversity component emphasizes the calculation model of the ratio of residential land area and non-residential land, in this case, can be measured by the balancing index formula (Sung & Choi, 2013).

Meanwhile, the design component's measurement is more complex than the other two components, with a system of assessing elements of the completeness of the pedestrian ways that adjusted to environmental conditions (Zhang et al., 2016). This study summarizes the design indicators needed to identify the appropriate pedestrian ways at the research location in the form of indicators of lane width, the number of lanes around, the number of road intersections, the presence of ramps, the presence of both bridges and zebra crossings, and the completeness of street furniture.

The country context has an essential role in determining the built environment assessment of pedestrian activities. The biggest question emerging from previous research is whether the context of the built environment in the European region will be the same as the context for the built environment in the Asian region. Research in downtown Montreal Canada shows that population density, commercial land use, number of jobs, number of schools, presence of metro stations, number of bus stops, percentage of major arteries, and an average length of roads are closely related to the pedestrian activity (Miranda-Morenoa et al., 2011). This city's position in the State of Canada is a provincial capital that is not included in the national capital area and is one of the cities located in developed countries. The problem faced in the provision of pedestrian ways in this area is the lack of pedestrians' security. This area has a pedestrian way element complete with skyscrapers around it. The provision of pedestrian ways in the City of Montreal adapts to the season conditions visible in the type of vegetation.

The discussion of the built environment on pedestrian ways in developing countries, namely the transit area in Bangkok, Thailand, obtained results in the form of an interplay between people's tendency to walk and the diversity of land use around the transit area (Townsend & Zacharias, 2010). Based on the same source, the sidewalk procurement condition in Bangkok, Thailand, is faced with air pollution and the lack of sidewalks and their complementary elements. The development of commercial, retail, and residential land is relatively high around the transit center so that the influence of the built environment component diversity is high enough on pedestrian movement patterns.

Meanwhile, research conducted in other Asian regions such as Beijing China obtained different results. The results on the built environment at environmental-scale transit centers in Beijing show that the density component plays a substantial role in influencing pedestrian activities (Zhao et al., 2018). The pedestrian ways component in this country is complete than the pedestrian ways procurement in Bangkok. Also, the influence of the vertical building construction policy in the central area of Beijing City is the basis for the formation of a compact city with relatively close distances between buildings (Zhao et al., 2018). The density of the built environment in this area influences a person's inclination to walk. In general, the geographic characteristics and scope of the research conducted in Bangkok and Beijing are relatively the same. It is carried out in areas with relatively flat homogeneous topography with environmental scale research coverage.

This research is conduct in the Semarang Metropolitan area, one of the cities in the Central Java Province of Indonesia that is the center for developing a transit-based transportation system in the form of the Trans Semarang Bus. Observation of the relationship between the built environment and pedestrian activities in the central transit area along the Trans Semarang Bus corridor is interesting because it covers the city center area to the suburban area with a flat to undulating topography. The problem of pedestrian ways procurement in Semarang City is the same as that of Bangkok, that is the form of pollution problems and the lack of pedestrian ways procurement. Research conducted by Purwanto and Manullang (2018) found that as many as 88% of Trans Semarang Bus passengers walked to and from bus stops. That is certainly in contrast to the lack of pedestrian ways procurement in the city of Semarang, which causes a gap between procurement and demand. Policies regarding land use regulated by City Territory Section (CTS) found that land use in Semarang City is very diverse.

The absence of a firm policy on building construction efforts has resulted in a high sprawl level in this area. So, this study aims to determine what kind of built environment model affects a person's tendency to walk along the Trans Semarang Bus corridor, from the city center to the suburbs. By referring to several research questions, such as; 1) what is the condition of the density, diversity, and design components of pedestrian activity and 2) how is the influence model obtained from the built environment on the tendency of walking activity in Semarang City with various environmental characteristics and the problem of lack of provision of pedestrian ways.

METHODS

Semarang Study Area

Semarang City is one of the metropolitan cities in Indonesia located in Central Java Province.The city experiences a population increase of more than 50% from year to year, accompanied by not optimal transportation systems available. This location is one of the pilot areas for BRT development in Indonesia with the procurement of Trans Semarang Buses in 2009 to improve the quality of the transportation system (SuaraMerdeka.com, 2015). The undulating topography with the uneven distribution of pedestrian ways along the Trans Semarang Bus corridor is interesting to study. Different land use and the phenomenon of urban sprawl towards suburban areas are the main attractions to determine their effects in assessing the components of the built environment on pedestrian activities. The location in this study covers all Trans Semarang Bus routes consisting of Corridors I, II, IIIA, IIIB, IV, V, VI, VII, and VIII that can be seen in Figure 1. A sampling of the observation area using the neighborhood level method with a radius of 200 meters from the right and left of the road that already picked up from the minimum average distance of the Trans Semarang Bus user's walking ability from the dwelling to the bus stop or vice versa. According to Kim et al (2018), there are two ways to measure the built environment based on the area's scope, namely the street level as far as 50 meters and the neighborhood level with a maximum radius of 400 meters from the observation point.

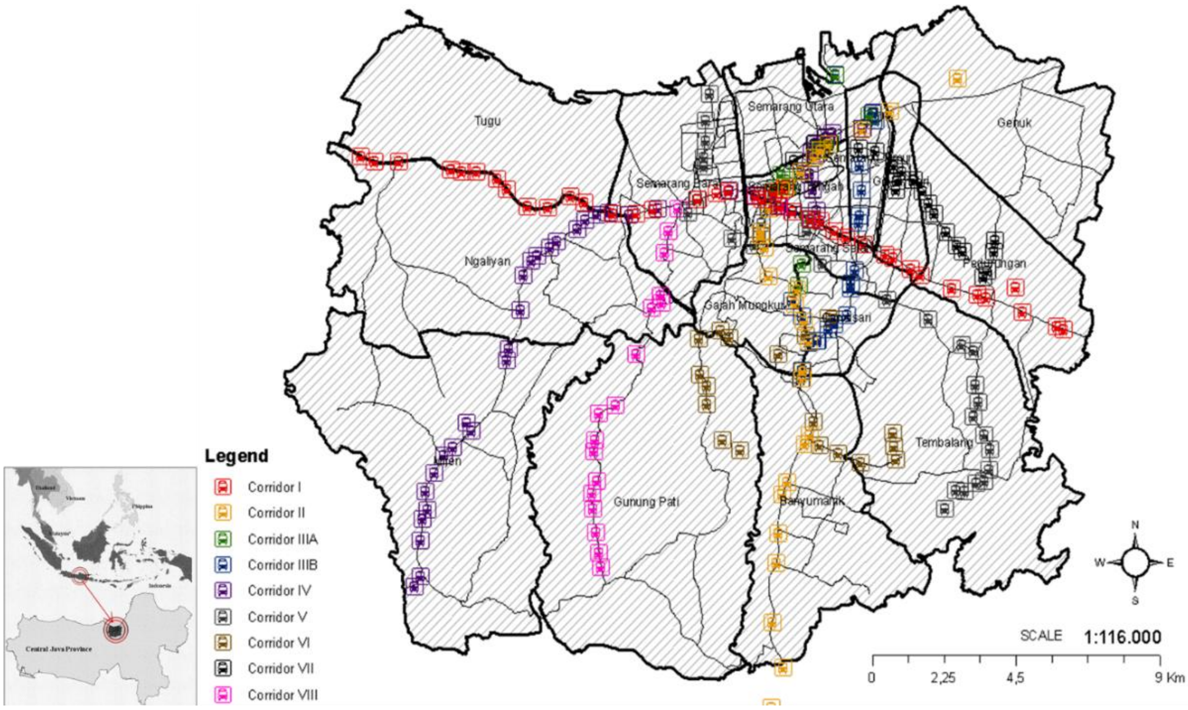


Figure 1. Trans Semarang bus stops in the study area

The entire Trans Semarang Bus corridor in this study has 596 bus stops scattered from the city center to the suburbs and connects various important land uses such as terminals, government centers, education centers, and other land uses can be seen in Table 1. Data from the Semarang City Transportation Office in 2018 shows a significant increase in the number of Trans Semarang Bus passengers from 2010 to 2018. The total number of passengers in 2010 was 369,326 passengers to 10,210,296 passengers in 2018. The number of passengers on Trans Semarang buses inclined to increase along with the increasing number of corridors (Rakhmatulloh et al., 2020). Most of the Trans Semarang Bus passengers are students aged 17-14 years old. As many as 88% of Trans Semarang Bus passengers walk to the bus stop and from the bus stop to the residence that can be seen in Table 1. The largest contributor for pedestrians in this study is Corridor I, which also has massive bus stops and fleets than the other eight corridors. Based on data from the results of field observations carried out, pedestrian activities along the Trans Semarang Bus corridor are dominated by work activities, going to or from school, and recreational activities. City center areas such as in Corridors I, II, and IV have more massive pedestrian activity than other corridors.

Table 1
Trans Semarang Bus corridor profile

Corridor	Rute	Number of			Corridor Length (Km)	Operating Years
		Pedestrian (People)	Bus (Unit)	Stops (Unit)		
I*	Mangkang Terminal → Penggaron Terminal.	2.713.852	25	81	60,0	2009
II	Terboyo Terminal →Sisemut Terminal.	838.081	34	74	26,5	2012
IIIA	Tanjung Emas Port → Kagok → Tanjung Emas Port.	166.934	16	45	10,5	2014
IIIB	Tanjung Emas Port → Elizabeth Hospital → Tanjung Emas Port.	111.289		40	10,0	2014
IV	Cangkiran Terminal → Semarang Tawang Station.	520.436	22	87	22,3	2013
V	Meteseh Residential Area → Airport → Marina Beach.	366.319	16	75	25,9	2017
VI	Diponegoro University → Semarang State University.	257.831	16	63	13,4	2017
VII	Terboyo Terminal → Semarang City Hall.	87.886	13	63	6,9	2018
VIII	Cangkiran Terminal → Simpang Lima (City Center).	56.799	20	68	22,4	2019

Note : *corridors with the most pedestrians

Methods

The method used in this research is a quantitative research method that focuses on analyzing the built environment in the form of density, diversity, and design. Retrieval of data for analysis needs using naturalistic observation techniques that see the research object's condition in a more real way directly to the field. Density analysis will assess population density by comparing the total population using the density interpolation method in ArcGIS 10.3. This analysis produces a spatial picture of population density in each corridor. The density component analysis will also use the numerical calculation method of Floor Area Ratio (FAR) by comparing the number of buildings per floor area. The calculations by Duduta (2013), divided into three categories, namely low density, medium density, and high density as follows:

$$\text{Low density} = \frac{\text{number of buildings 1–2 floors}}{\text{the total number of buildings within a 200 meter radius of the stop point}} \quad [1]$$

$$\text{Medium density} = \frac{\text{number of buildings 3–8 floors}}{\text{the total number of buildings within a 200 meter radius of the stop point}} \quad [2]$$

$$\text{High density} = \frac{\text{number of buildings >8 } floors}{\text{the total number of buildings within a 200 meter radius of the stop point}} \quad [3]$$

Diversity components were analyzed using the land use ratio analysis by comparing the land as residential, commercial, office space, public services, and recreation to the total land area around the Trans Semarang Bus stop in each corridor. According to Sung and Choi (2013), this diversity of land uses can be explain using the balancing index (RNR index) formula by comparing non-residential land use (i) with residential land.

$$RNRi = 1 - [\frac{\text{Res}-\text{Non res}}{\text{Res}+\text{Non res}}] \rightarrow \text{The closer to 1, the more balance} \quad [4]$$

Meanwhile, analyzing the design component can be done by looking at the road structure and the completeness components of pedestrian ways based on pedestrian movement needs. In this case, the assessment indicators are elements of the completeness of the crossing, ramps, the presence of intersections, the width of the pedestrian ways, the number of lanes, and pedestrian ways furniture. This component of the analysis will be presented to visualize the existing conditions and compare them with the required pedestrian component demand data in Semarang. The overall results of the density, diversity, and design analysis were processed using the significance of linear regression (simultaneous F test) using the SPSS Statistics 24 application to determine the effect of the built environment on walking activities in each corridor. Linear regression has been widely used in previous research to produce a model of the relationship between the built environment variables and pedestrian movement patterns in an area. The terms of the linear regression analysis (simultaneous F test) are if the ANNOVA F result is greater than the F table of 6.61 and the significance value of the data regression results is less than 0.05 (<0.05), then there is a significant relationship between the variables. dependent and independent variables, or both variables influence each other. The built environment variable consisting of density (X1), diversity (X2), and design (X3) as independent variables is correlated with the dependent variable in the form of pedestrian intensity in each corridor (Y) can be seen in Figure 2.

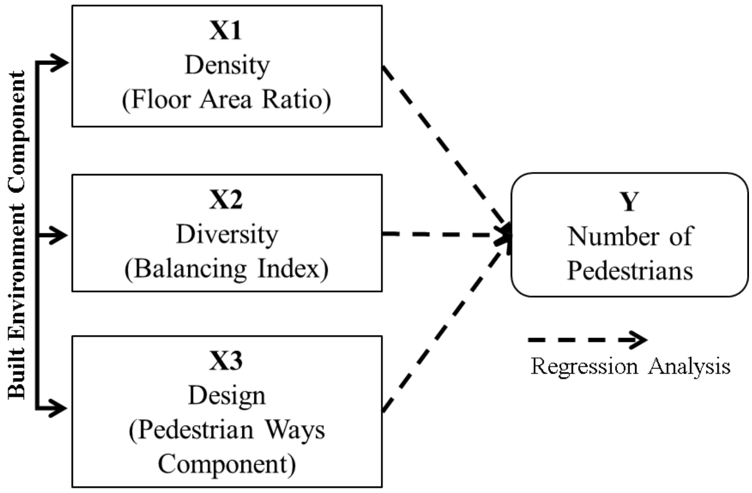


Figure 2. Linear regression analysis diagram

RESULT AND DISCUSSION

Density Analysis

The density is one component of the built environment that can be measured by observing population density per household or building density per unit area of land in the area (Cervero & Kockelman, 1997). The city growth theory states that the average city in the world has a relatively similar development pattern, such as the closer to the city center, the population density will be higher (Fee & Hartley, 2011), the same is the case in Semarang City can be seen in Figure 3. That is due to the existence of a trip generation between the city center and the suburbs. Within a 200 meter radius of the Trans Semarang Bus stop, corridors with the shortest coverage such as corridors IIIA and IIIB serving downtown areas tend to be affected by high population density. A large population will tend to increase the number of travel requests and the quality of BRT container services to meet population mobility (Patankar et al., 2007).

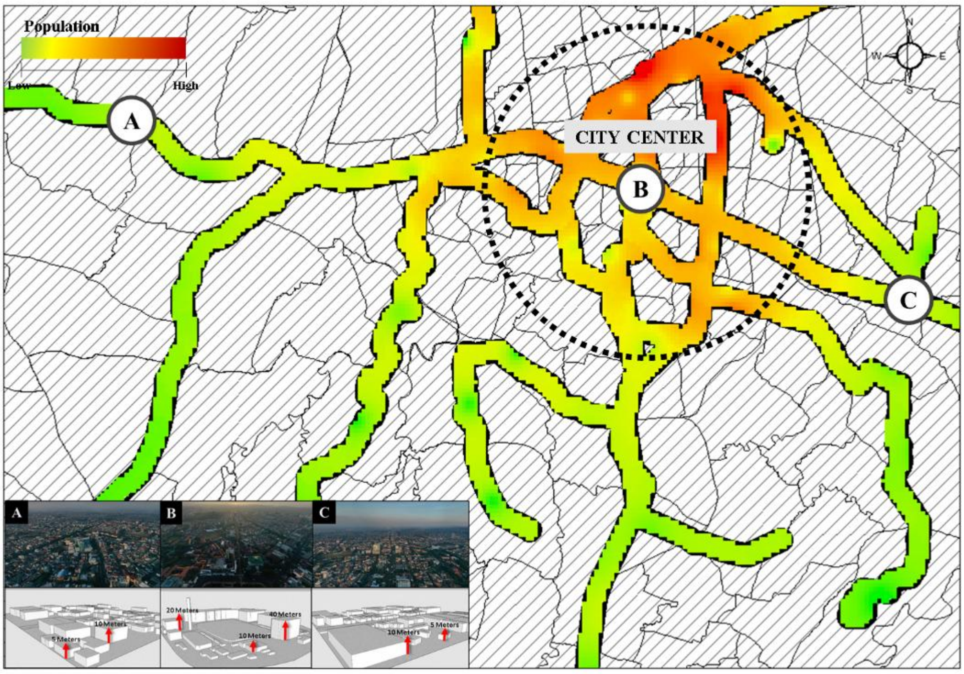


Figure 3. Population density and FAR (buffer area 200 meters)

The calculation of density values in Table 2 about condition of the element density of each corridor found that Corridor IIIB has the highest total density compared to other corridors. The density that occurs in this corridor is dominated by 1-2 floors buildings, indicated by the low-density value reaching 0.983. Data from field observations show that the entire Trans Semarang Bus corridor that dominated by developments in a horizontal direction following the road network. Research on transportation hubs in Japan found that a high Floor Area Ratio (FAR) value with optimized construction of vertical buildings would improve land use quality and create effectivity movement for pedestrians (Yang & Yao, 2009). This means that the Trans Semarang Bus corridor's construction conditions have not been implemented optimally because there have not been many vertical buildings implemented.

That has implications also for the tendency of sprawling regional development in developing countries such as Indonesia, which causes low regional compactness so that the location of the central functions of activities is far apart. The evidenced by the calculation results in Table 2 about condition of the element density of each corridor, which shows that of the nine corridors, only three corridors that have a relatively high-density value (33%). Of course, this causes pedestrians' distance to specific locations to be further away, thereby reducing the community's interest to carry out walking activities from one place to another. Relevant to the research by Florez et al (2014), quality pedestrian ways are determined by area accessibility and ease of access. In general, Semarang's maximum walking ability is only 250 meters between destination locations (Purwanto & Manullang, 2018).

Table 2
The condition of the element density of each corridor

Corridor	Building			radius 200 meters (unit)	Lenght (Km)	Large (Ha)	Total Density (unit/Ha)	Density		
	1-2 floors (unit)	3-8 floors (unit)	>8 floors (unit)					Low	Medium	High
(1)	(2)	(3)	(4)	(5)	(6)	200*(6) = (7)	(5)/(7)	(2)/(5)	(3)/(5)	(4)/(5)
I	4.358	290	8	4.656	60,0	1.200	4	0,897	0,096	0,007
II	3.833	130	3	3.966	26,5	530	7	0,960	0,043	0,001
IIIA	3.258	84	6	3.348	10,5	210	16	0,958	0,039	0,003
IIIB*	6.249	85	6	6.340	10,0	200	32	0,983	0,016	0,001
IV	714	167	21	902	22,3	446	2	0,758	0,172	0,028
V	968	152	18	1138	25,9	518	2	0,817	0,164	0,039
VI	3.587	121	0	3.708	13,4	268	14	0,936	0,064	0,000
VII	654	110	2	766	6,9	138	6	0,824	0,149	0,002
VIII	171	96	7	274	22,4	448	1	0,632	0,341	0,027

Note : *corridor with the highest density

The density analysis results along the Trans Semarang Bus corridor are contrary to the results of research conducted by Zhao et al (2018), dominance of the density component's effect on the built environment on pedestrian activity in Beijing is a high-density category. Low-income people in Beijing prefer traveling by foot rather than using motorized vehicles. In line with the Chinese government's policy of intensifying vertical development to implement a sustainable city policy. It is different from the condition of existing regulation in Semarang, which has not emphasized vertical development. As a result, the building density pattern is not evenly distributed, especially towards the suburban area, using less optimal land (overlay). That has an impact on the lack of a person's desire to walk in the area.

Diversity Analysis

The assessment of the built environment components of diversity in this study was carried out by looking at the balancing index value from comparing residential and non-residential (commercial) land areas. Table 3 about condition of the element diversity for each corridor, shows the results of balancing index calculations in each corridor, where the entire corridor shows a balancing index value close to 1. According to Sung and Choi (2013), the balancing index value is close to one categorized as an area with mixed land use with a high balancing value. The highest balancing index value is in the Corridor II area. The result of the balancing index value in this corridor is 1.110 with the main designation as a trade and service center.

Its function as a center for trade and services has made this area experience increasingly diverse land uses.

The proportion of residential and non-residential land in this area is very stable, with a residential area of 60 hectares and a non-residential area of 59 hectares within a 200-meter radius from the transit center. As one of the longest corridors, Corridor I has the smallest balancing index value compared to other corridors, which is only 0.395 (getting away from 1). The proportion of residential land area with non-residential land in this corridor is in the unbalanced category. Residential land reaches 98.70 hectares, while for non-residential areas dominated by trade and services, offices, and industry, only 40.22 hectares. This is in line with research conducted in Bangkok, which states that pedestrians' potential is greatly influenced by various land uses (Townsend & Zacharias, 2010). However, areas with non-commercial land-use values in Bangkok City more influence a person's potential for walking.

Table 3
Condition element diversity for each corridor

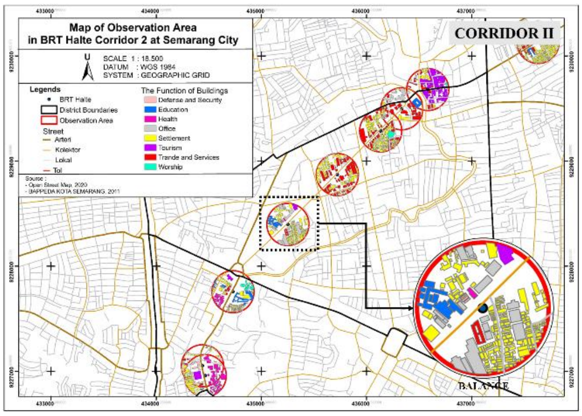
Corridor	Res (Ha)	Non-res (Ha)	Balancing Index	Landuse
	(1)	(2)	(1)/(2) = (3)	(4)
I**	98,70	40,22	0,395	Settlements, industry, trade and services, warehousing, worship, defense and security, offices, education, health, recreation, public spaces, sports.
II*	60,59	58,72	1,110	Offices, trade and services, police education and sports, industry, and housing.
IIIA	64,58	89,44	0,831	Defense and security, education, health, offices, public spaces,
IIIB	56,55	23,04	1,184	recreation, settlements, trade and services, and worship.
IV	261,32	339,46	0,870	Offices, worship, health, trade and services, education, housing, recreation, defense and security, and transportation.
V	215,86	311,21	0,820	Education, health, industry, offices, defense and security, housing, sports, recreation, trade and services, and worship.
VI	57,68	31,10	1,314	Defense and security, education, health, offices, settlements, recreation, trade and services, and worship.
VII	129,01	247,47	0,685	Education, health, industry, offices, defense and security, housing, sports, recreation, trade and services, and worship.
VIII	158,80	167,19	0,938	Trade and services, worship, health, education, offices, recreation, defense and security, and settlements.

Note : Res (Residential area), Non-res (Non-residential area): *corridor with the highest balancing index ; **corridor with the lowestt balancing index.

The location of the highest balancing index for Corridor I is the same as that of Corridor VIII, namely at the Amarta bus stop point that can be seen Figure 4 section h. The balancing index value at this point is 1.10, which is dominated by non-residential land use in trade and services. The locations with the highest balancing index at the Corridor II area is City Hall bus stop that can be seen in Figure 4 section a. The balancing index value at this point is 0.96 with the dominance of non-residential land use in the form of offices and educational buildings. Meanwhile, for Corridor IIIA, the location with the highest balancing index value is at the point of the Raden Patah bus stop that can be seen in Figure 4 section b. The balancing index value at this point is 1.06, with the dominance of non-residential land use in the form of trade and services and school buildings. The highest balancing index value for Corridor IIIB has located at the Don Bosco stopping point that can be seen in Figure 4 section c, with a value of 1.06. The dominance of land use in this corridor is the use of residential land in housing and school buildings.

The location with the highest balancing index value is in the Corridor IV area, namely at the Nyaliyan Square stop that can be seen in Figure 4 section d, with a value of 0.99. The dominance of land use in this corridor uses non-residential land in the form of trade and services and educational buildings. Meanwhile, based on Figure 4 section e in the Corridor V area, the highest balancing index value is at the Karangayu bus stop point with 1.00 (very balanced). The dominance of land use in this corridor is a land-use Settlement. The location with the highest balancing index value in Corridor VI is at the Diponegoro University Nursing stop (educational area) with a value of 1.04. Based on Figure 4 section f, it can be seen that the dominance of land use in this area is non-residential land use in the form of educational buildings. Meanwhile, for the highest balancing index, Corridor VII is located at the Petek bus stop that can be seen in Figure 4 section g. The balancing index value at this point is 0.99, with the dominance of non-residential land use in the form of trade and services.

In general, the diversity analysis results for all Trans Semarang Bus corridors have the same pattern as the results of the balancing index. Where locations with a high balancing index value are dominated by land use as trade and services also education. Relevant to the research results by Miranda-Morenoa et al (2011), which states that the existence of school buildings and commercial areas significantly affects the pedestrian tendency pattern of each individual. This is also in line with research on pedestrian patterns in the City of Bangkok that states the pedestrian’s intensity will be longer at locations with functions as offices or centers of trade and services compared to other functions (Townsend & Zacharias, 2010). Based on field observations, the areas designated for trade and services at the research location tend to be full of activity from morning to evening. However, areas designated for education and offices such as those located in the center of Semarang City will tend to be quiet from late afternoon to late evening because, at that time, students and office workers are not active. So that various land uses in an area are needed to increase activity patterns to optimize land use. Because the use of pedestrian facilities will not be sustainable in an area with minimal activity, resulting in a less functional existence of pedestrian ways in the area. Also, areas with mixed land use characteristics on foot will feel more attractive because the resulting activities are more diverse (Untermann et al., 1984).



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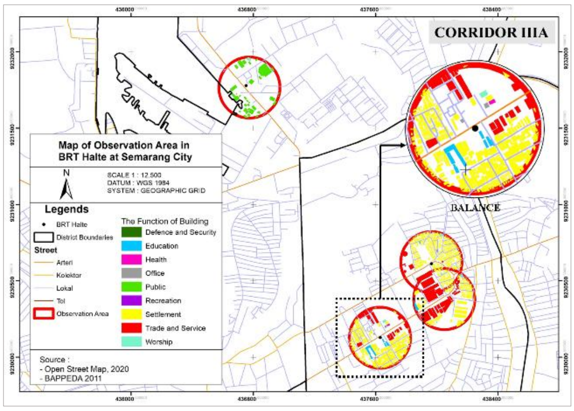

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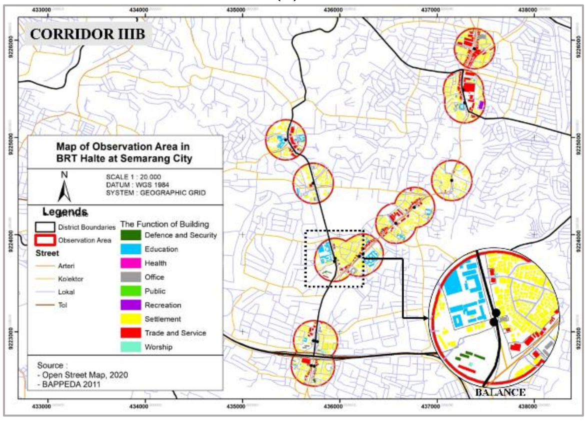

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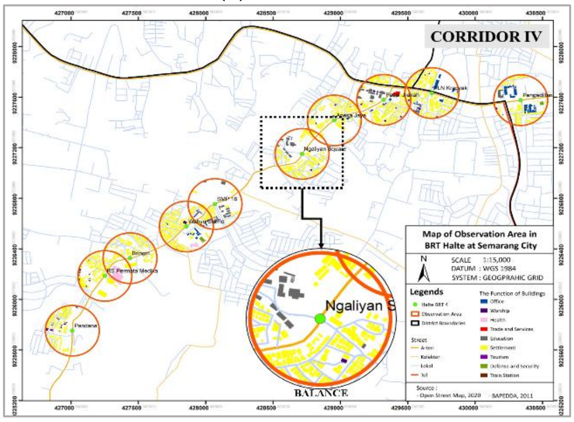

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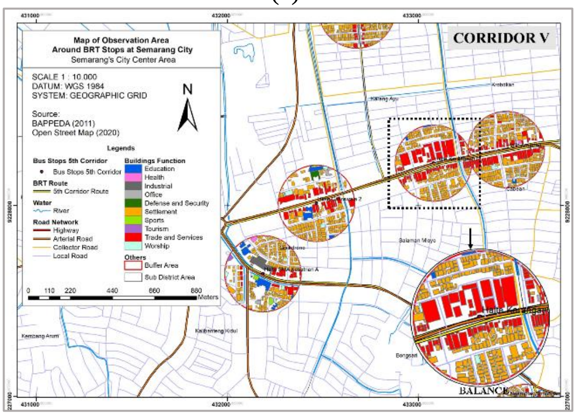

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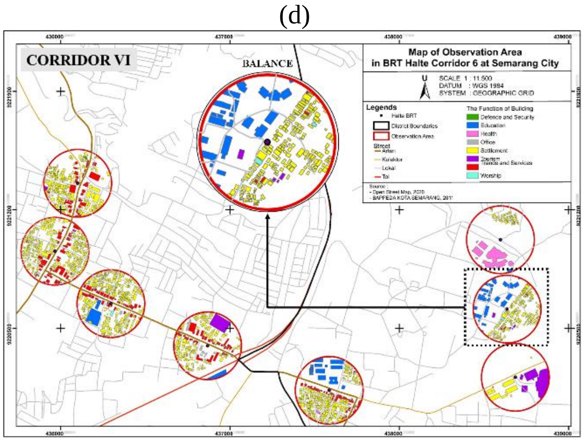

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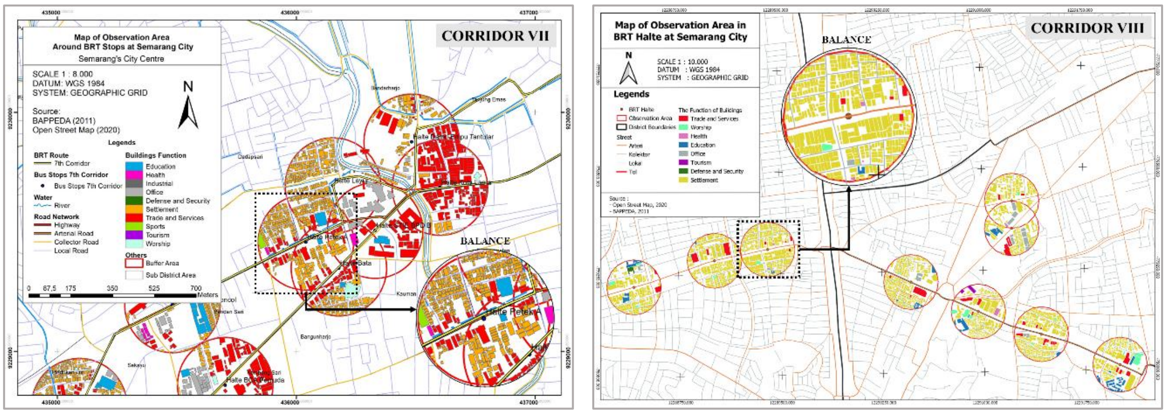


(g) (h)

Figure 4. The highest balancing index value; (a) Corridor II, (b) Corridor IIIA, (c) Corridor IIIB, (d) Corridor IV, (e) Corridor V, (f) Corridor VI, (g) Corridor VII, (h) Corridor I & VIII.

Design Analysis

Design elements such as road structure, area design, city shape, number of intersections, average area block size, number of pedestrian bridges, number of intersections, and others are several benchmarks in assessing the effect of the artificial environment on pedestrians (Cervero & Kockelman, 1997). In general, according to the results of research conducted by Purwanto and Manullang (2018), it is stated that Trans Semarang Bus users, especially pedestrians, still consider the lack of adequate supporting facilities for pedestrians with the lowest level of assessment compared to other elements such as integration with transportation and security modes. The research on pedestrian ways design components in the built environment is rarely done compared to the other two components. This is because the design component has quite complex indicators according to the observed location's environmental conditions.

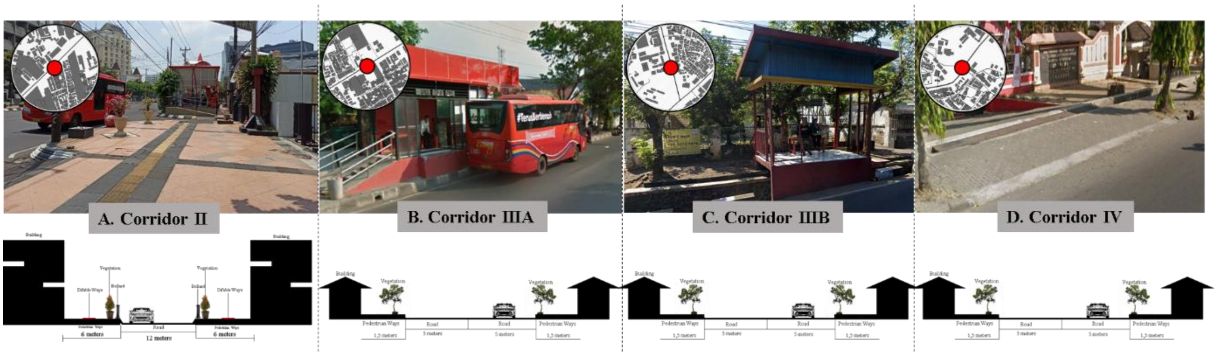
Table 4
Complete pedestrian ways design for the Trans Semarang Bus corridor

Corridor	Pedestrian Ways Large (m)	Lanes of the road (lanes)	Number of			Street Furniture
			Inter sections	Ramp	Crossings	
I*	1 - 5	2 – 6	172	267	42	Shade vegetation, bollards, lights, trash cans, traffic signs, seats, special lanes for the disabled.
II*	1 - 5	2	165	138	38	Traffic signs (no stopping sign, no parking), street lights, ways with disabilities, and potted vegetation.
IIIA	1 – 5	1 - 2	95	3	13	Lights, bollards, vegetation, traffic signs, trash cans, fire hydrants.
IIIB	1 – 1,5	1 - 2	246	0	22	Shade vegetation, and traffic signs.
IV*	1 - 3	2 - 4	110	396	30	Shade vegetation, bollards, lights, traffic signs, and special lanes for the disabled.

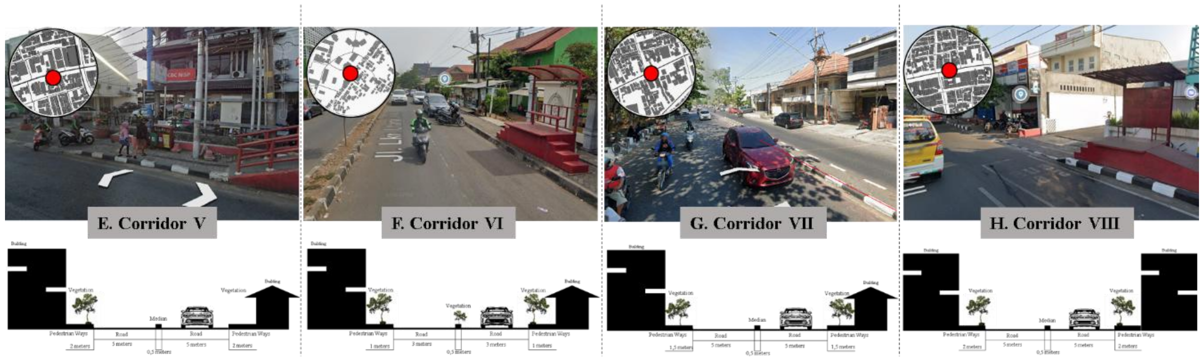
Corridor	Pedestrian Ways Large (m)	Lanes of the road (lanes)	Number of			Street Furniture
			Inter sections	Ramp	Crossings	
V	0,5 - 2,5	1 - 2	170	27	31	Shade vegetation, lights, traffic signs, benches, and special lanes for people with disabilities.
VI	1 - 3	2	132	40	18	Traffic lights and signs.
VII	1 - 2,5	1 - 2	127	21	12	Shade vegetation, lights, traffic signs, and ways for the disabled.
VIII	1 - 3	2 - 6	24	184	16	Shade vegetation, special lanes for people with disabilities, and traffic signs.

Note : corridor with the most complete design elements

Based on the pedestrian ways design analysis, the results are that Corridors IV, I, and II are corridors with the largest number of ramps, crossings, and the presence of deviations compared to other corridors that can be seen in Table 4. When compared with the pedestrian data in Table 1 about Trans Semarang Bus corridor profile, it can be seen that there is a linear trend pattern. Corridors with the highest number of pedestrians tend to have more complete pedestrian facilities. Another indication is that the closer to the city center area with a denser population activity level, the better and more complete the pedestrian ways design will be. Some locations in the periphery areas such as those on the outskirts traversed by Corridor VI only have pedestrian ways that are 1-2 meters wide and are only equipped with vegetation that can be seen in Figure 5. This is relevant to the research results conducted by Purwanto and Manullang (2018), which states that the condition of the Trans Semarang Bus sidewalks, especially in the suburbs of Semarang City, still needs improvement, because there is still a gap between current conditions and user expectations. The elements that need to be improved are lighting, seats, weather protection, and the sidewalk ramp's slope.



(a) Sample of pedestrian ways ; corridor II, corridor IIIA, corridor IIIB, dan corridor IV.



(b) Sample of pedestrian ways ; corridor V, corridor VI, corridor VII, and corridor VIII.
Figure 5. Pedestrian ways conditions throughout the Trans Semarang Bus corridor

In general, pedestrian ways near trade and service centers tend to be directly connected to building entrances. Different from the existing pedestrian ways in residential areas, which are usually limited by vegetation or drainage. Research conducted on pedestrian ways in Bangkok found that walking distance to shopping and work is more extended than walking distance to food places (Townsend & Zacharias, 2010). Economic principles such as the supply of goods take a long time with large space to move. So it is not uncommon for city center locations to provide pedestrian ways that are wide enough to accommodate complex resident activities. When viewed based on Trans Semarang Bus users' characteristics, it shows that around 18% of the trips made by Trans Semarang Bus passengers are for entertainment activities such as shopping or recreation (Purwanto & Manullang, 2018).

Built Environment Influence Model on Pedestrians

Based on the linear regression test results using the simultaneous F test method to determine the significance of the relationship between two or more variables. Two things can be used as benchmarks in this method, namely the ANNOVA F results and the significant results. The dependent variable is the number of pedestrians passengers of the Trans Semarang Bus per corridor (Y), and the independent variable is a built environment component consisting of the total density (X1), balancing index diversity (X2), and the number of pedestrian lane design elements (X3), a radius of 200 meters.

Based on Table 5 about the results of linear regression data processing (simultaneous F test), which obtained ANNOVA F value of variable density (X1) of 0.593 and a significance value of 0.466. This means that the density-independent variable (X1) does not significantly influence the dependent variable pedestrian intensity (Y) because of the calculated F value <F table 6.61 and the significance value is greater than 0.05. Also, the

resulting data is not normally distributed because it has an Adjusted R^2 value of -0.054 away from 1 (normality standard value).

Based on the same table, it shows that the independent variable diversity (X2) has an ANNOVA F value of 72.215 (> 6.61) and a significance calculated value of 0.001 (<0.05), which indicates a significant relationship between the dependent variable pedestrian intensity. (Y) with the independent variable diversity (X2). The independent variable in the form of diversity can affect the intensity of pedestrians at the research location, with the direction of the positive influence, namely the more balanced land use in an area, the more a person's desire to walk. Diversity component data is normally distributed, indicated by an Adjusted R^2 value of 0.912 close to 1 (normality standard value).

Based on the same table, it shows that the independent variable design (X3) does not have a significant relationship with the dependent variable pedestrian intensity (Y). This is because this variable has an F calculated value of 5.120 which is smaller than F table 6.61, and the results of the calculation of significance are greater than the standard of tolerance of 0.05. Also, the processed data is not normally distributed because the Adjusted R^2 value is 0.340 or away from 1 (normality standard value).

Table 5

The results of data processing linear regression (simultaneous F test) SPSS

Code	Independent Variable	R^2	Adjusted R^{2*}	ANNOVA F**	Sig***
X1	Density (Floor Area Ratio calculation results)	0,078	-0,054	0,593	0,466
X2	Diversity (The ratio of residential and non-residential land or Balancing Index)	0,912	0,899	72,215	0,001
X3	Design (The completeness of the pedestrian ways elements)	0,422	0,340	5,120	0,058

Note : The F table value is 6.61 : * The closer to 1, the data is normally distributed.;** If F count> F the data table has a close relationship; ***Sig <0,05 has a significant relationship meaning.

The results of the model of the influence of the built environment on pedestrian activity in Semarang are relevant to research conducted in the City of Montreal, Canada. The results suggest that land diversity can influence a person's tendency to walk uses around the transit center (Miranda-Morenoa et al., 2011). Similar to the research results in the city of Semarang, land use as a center for trade and services and school buildings dominates the goals of pedestrian movement in the City of Montreal, Canada. Likewise, the research results in Bangkok, the use of commercial land, tends to encourage someone to walk around transit centers (Townsend & Zacharias, 2010). The environmental conditions along the transit-based transportation routes in Bangkok City have the closest characteristics to this research. The characteristics of building density and land use are relatively spread out, from the city center to the suburbs. Another similarity is that the pedestrian ways are not optimal.

The difference between the study results and previous research lies in the coverage of the research area, topographical conditions, and urban development policies. Montreal and Beijing China's Canadian city tends to influence the density component on a person's willingness to walk because of the flat topography, the relatively close distance between buildings and transit centers, and supporting vertical development policies. Also, the pedestrian design elements in this area are relatively complete when compared to Semarang City and Bangkok City of Thailand. The following is a diagram of the resulting model in Figure 6.

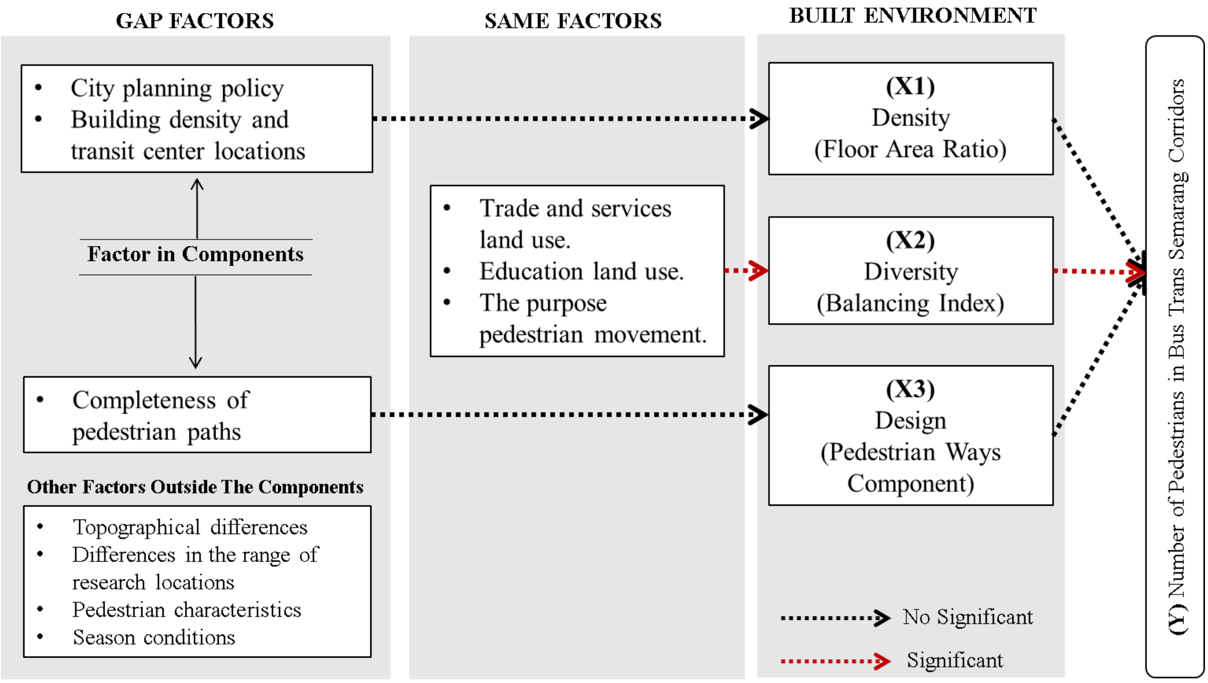


Figure 6. Model diagram analysis influence of the built environment and pedestrian activity.

CONCLUSION

The calculation result shows the density conditions along the Trans Semarang Bus corridor. Most of the 200-meter radius area from the Trans Semarang Bus stop is in the low-density category with an average building height of 1-2 floors (5-10 meters). Vertical development is still minimal, especially in suburban areas, causing accessibility between activity centers to be far from one another. This is also due to the tendency for population growth to occur sprawl from the center to the suburbs, which causes less optimal services for public facilities, which include public transportation.

While the condition of the diversity that found from the calculation of the balancing index for residential land use against non-residential land use. In general, land use in a radius of 200 meters from the transit center on the pedestrian ways is in the high category because the balancing index value is close to 1. The location with the highest balancing index value on each Trans Semarang Bus corridor has the same characteristics, which is dominated by land use as trade and services and education. These results are relevant to research conducted in Montreal (Canada) and Bangkok (Thailand) (Miranda-Morenoa et al., 2011), (Townsend & Zacharias, 2010). The condition of the design components in each corridor generally has the same pattern. Pedestrian ways of completeness elements such as ramps, crossings, road intersections, and other supporting elements tend to approach the city center more completely.

The calculation of the built environment model uses the linear regression analysis method. Simultaneous F test between the dependent variable pedestrian intensity (Y) with the independent variable, in the form of components of density (X1), diversity (X2), and design (X3). The results of the calculation of the linear regression model show that there is a significant relationship between pedestrian intensity and environmental diversity (balancing index). The model relationship showed a positive value that means the higher the value of the balancing index, will increase the intensity of pedestrians in an area. Factors that influence the model formation are trade and service land-use factors as well as education.

Then, the factors that differentiate it from previous research, such as those that conducted in Montreal Canada, Beijing China, and Trans Semarang Bus Corridor I are urban planning regulations, building density, and completeness of pedestrian ways components. Other factors outside the components that distinguish the results of this study from previous studies are topographic characteristics, the range of the research location, season conditions, and pedestrian characteristics. The research results that expected to be the basis or reference in developing science and further research with relevant topics. At the same time, as input for Semarang development policymakers in the provision of pedestrian ways that has integrated with a sustainable public transportation system.

ACKNOWLEDGEMENTS

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Built Environment and Its Impact on
Transit Based Transportation User Walking Activities

Built Environment and Its Impact on Transit Based Transportation User Walking Activities in Semarang, Indonesia

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List of Table/Figure:

ABSTRACT

The pedestrian ways are a feeder facility that connects the transit system in transportation, the Bus Trans Semarang as transit-based transportation, as many as 88% of passengers walk from and to bus stops. However, the current pedestrian ways do not meet the needs of pedestrians in the surrounding environment. So it can be seen how the built environment such as density, diversity, and pedestrian ways design can influence each other on Semarang's pedestrian conditions. The result of regression analysis using the partial T-test shows a significant relationship between the components of diversity and the potential for people to walk compared to density and design elements. The level of land use mix along the Bus Trans Semarang corridor is relatively high, as seen from the balancing index calculation. The use of land for trade and services and also education is the main attraction for pedestrians of Bus Trans Semarang passengers to carry out walking activities. Lack of vertical development and low density between buildings causes fewer density components to influence people's desire to walk. The lack of complete pedestrian facilities in design components causes a low level of security and user comfort. Also, there are findings of factors that play a role in shaping the regression results and differentiating research results from previous studies. Commercial and educational land use (diversity correlation factor); regulations, urban density, completeness of pedestrian ways (differentiating factors in components); and topography, site range, pedestrian characteristics, season (differentiating factors excluding components).

Keyword : Built Environment, Transit Based Transportation, Pedestrian Ways.

INTRODUCTION

The development of a transit-based transportation system is being done intensively in various Asian countries as an alternative in suppressing population growth and private transportation. The Asian region has become the axis of developing an unhealthy transportation system that causes various problems, such as congestion, air pollution, and sprawl problems (Makarova et al., 2017). To overcome this, the World Health Organization (WHO) encourages countries to implement sustainable transportation systems that focus on safe, efficient, accessible, affordable, inclusive, green, healthy mobility and transportation.

A Transit-Oriented Development (TOD) is a form of sustainable transportation that emphasizes integrating urban spatial design to unite people, activities, buildings, and public spaces through connectivity that can be accessed by walk (Institute for Transportation & Development Policy, 2017). Increasing the intensity of walking (walkability) is considered as one of the effective solutions in overcoming unhealthy transportation because it can minimize congestion, increase environmental sustainability, encourage physical activity, improve public health, and improve the appropriateness of urban settlements (Blanco & Alberti, 2009). The pedestrian ways are commonly referred to as a sidewalk in a transit-based transportation system is a facility feeder that connects a transit center in the form of a stop with other activity functions in its surrounding area (Hu et al., 2013). However, the lack of optimal pedestrian ways in several countries is a challenge for the procurement of a sustainable transportation system.

Various studies suggest that the optimization of pedestrian ways such as the completeness of design components, an attractive, safe, and comfortable city shape are increased residents' tendency to walk to a destination (Özbil et al., 2015). Changes in the built environment, such as land-use planning and urban design, are also crucial in increasing pedestrian activity in cities (Timmermans, 2009). Research on the relationship between the conditions of the built environment and the tendency to walk in the transit-based transportation system is still rarely. Various parties inclined to be focus on the opportunity to increase procurement of the transportation system without seeing how developments that occur affect the environment. As a result, the development of a new transportation system can be linear with uneven distribution of building density and land use that results in several pedestrian ways, not right functioning.

Developing the built environment in the transit-based transportation system is closely related to countries in the European region. The initial milestone in research on the built environment was first carried out by Cervero with looking at the context of the built environment in the European region as an agenda to welcome new urbanism concept. In the same source, formulated three main components in assessing the built environment in the form of density, diversity, and design. The density that defined as the component produced by observing population density per household and building density per area (Cervero & Kockelman, 1997; Monteiro & Campos, 2012; Zhang et al., 2016). Research on the built environment and pedestrian activity in previous studies found that areas with a high level of density had more influence on the intensity of people walking (Oktaviani et al., 2020). The diversity component that represented as a land-use balancing index by comparing the ratio of residential and non-residential (commercial) land use. The higher the level of balancing land use in an area, the pedestrian activity would increase (Sung & Choi, 2013). The design component is one of the components that refer to assessing the pedestrian ways completeness and its integration with the road network system (Dixon, 1996; Munshi, 2016). In detail, the pedestrian ways design attribute has less effect than the other two variables because it is necessary to relate to the surrounding demographic conditions and land use diversity (Cervero & Kockelman, 1997).

Along with the development of science, assessing the components of the built environment is also increasingly diverse. A study conducted by Duduta (2013), developed indicators for assessing density components in the form of building density measurements, which are related to building height or what is known as the Floor Area Ratio (FAR) analysis method. In the same source, takes a minimum distance of 200 meters from the stop point and divides it into three categories of density level assessment, that is low density (building 1-2 floors), medium density (building 3-8 floors), and high. density (building >8 floors). Simplifying the research of Cervero and Kockelman (1997), the diversity component emphasizes the calculation model of the ratio of residential land area and non-residential land, in this case, can be measured by the balancing index formula (Sung & Choi, 2013).

Meanwhile, the design component's measurement is more complex than the other two components, with a system of assessing elements of the completeness of the pedestrian ways that adjusted to environmental conditions (Zhang et al., 2016). This study summarizes the design indicators needed to identify the appropriate pedestrian ways at the research location in the form of indicators of lane width, the number of lanes around, the number of road intersections, the presence of ramps, the presence of both bridges and zebra crossings, and the completeness of street furniture. The country context has an essential role in determining the built environment assessment of pedestrian activities. The biggest question emerging from previous research is whether the context of the built environment in the European region will be the same as the context for the built environment in the Asian region.

Research in downtown Montreal Canada shows that the components of built environment density (population density, number of jobs, number of schools, number of bus stops), diversity (commercial land use), and design (percentage of main arteries, average length of roads) can affect pedestrian activity (Miranda-Morenoa et al., 2011). This city's position in the State of Canada is a provincial capital that is not included in the national capital area and is one of the cities located in developed countries. The problem faced in the provision of pedestrian ways in this area is the lack of pedestrians' security. This area has a pedestrian way element complete with skyscrapers around it. As a four-season country, the provision of vegetation along the pedestrian ways in the city is designed to suit seasonal conditions. Because, city designs that can adapt to climate change and seasons are being intensified to create sustainable urban life.

The discussion of the built environment on pedestrian ways in developing countries, that is the transit area in Bangkok, Thailand, obtained results in the form of an interplay between people's tendency to walk and the diversity of land use around the transit area (Townsend & Zacharias, 2010). The sidewalk condition in Bangkok, Thailand, is faced with air pollution and the lack of sidewalks and their complementary elements (Townsend & Zacharias, 2010; Chalermpong, 2007). Based on the same source, the development of commercial, retail, and residential land is relatively high around the transit center so that the influence of the built environment component diversity is high enough on pedestrian movement patterns.

Meanwhile, research conducted in other Asian regions such as Beijing China obtained different results. The results on the built environment at environmental-scale transit centers in Beijing show that the density component plays a substantial role in influencing pedestrian activities (Zhao et al., 2018). Based on the same source, the pedestrian ways component in this country is complete than the pedestrian ways procurement in Bangkok. Also, the influence of the vertical building construction policy in the central area of Beijing City is the basis for the formation of a compact city with relatively close distances between buildings. The density of the built environment in this area influences a person's inclination to walk. In general, the geographic characteristics and scope of the research conducted in Bangkok and Beijing are relatively the same. It is carried out in areas with relatively flat homogeneous topography with environmental scale research coverage.

Semarang is one of the major cities in Indonesia which is located in Central Java Province. The city with a total population of 1,79 million people plans to develop a Transit Oriented Development (TOD) system to accommodate the mobility needs of the population and create a sustainable transportation system. One of the embryos for the development of the TOD system in Semarang City is the Bus Trans Semarang. Observation of the relationship between the built environment and pedestrian activities in the central transit area along the Bus Trans Semarang corridor is interesting because it covers the city center area and its surroundings with a flat to undulating topography. The problem of pedestrian ways procurement in Semarang City is the same as that of Bangkok, that is the form of pollution problems and the lack of pedestrian ways procurement. Based on data, found that as many as 88% of Bus Trans Semarang passengers walked to and from bus stops (Purwanto & Manullang, 2018). That is certainly in contrast to the lack of pedestrian ways procurement in the city of Semarang, which causes a gap between procurement and demand. Policies regarding land use regulated by City Territory Section (CTS) found that land use in Semarang City is very diverse.

The absence of a firm policy on building construction efforts has resulted in a high sprawl level in this area. So, this study aims to determine what kind of built environment model affects a person's tendency to walk along the Bus Trans Semarang corridor, from the city center to the suburbs. With a research question in the form of, do the built environment components affect the pedestrian activity of transit-based transportation users in Semarang City?.

METHODS

Semarang Study Area

Semarang City is one of the metropolitan cities in Indonesia located in Central Java Province that have 1,79 million population. According to data from the Semarang City Statistics Center in 2019, the population of Semarang City has increased by 50% from year to year, accompanied by the provision of a public transportation system that is not yet optimal. This location is one of the pilot areas for Bus Rapid Transit (BRT) development in Indonesia with the procurement of Bus Trans Semarang in 2009 to improve the quality of the transportation system (SuaraMerdeka, 2015). The undulating topography with the uneven distribution of pedestrian ways along the Bus Trans Semarang corridor is interesting to study. The location in this study covers all Bus Trans Semarang routes consisting of Corridors I, II, IIIA, IIIB, IV, V, VI, VII, and VIII that can be seen in Figure 1. According to Kim et al. (2018) there are two ways to measure the built environment based on the area's scope, that is the street level as far as 50 meters and the neighborhood level with a maximum radius of 400 meters from the observation point. The data shows that the maximum population of Semarang City for walking is only 200-250 meters between destination locations (Purwanto & Manullang, 2018). So that, sampling of the observation area using the neighborhood level method with a radius of 200 meters from the right and left of the road that already picked up from the minimum average distance of the Bus Trans Semarang user’s walking ability from the dwelling to the bus stop or vice versa.

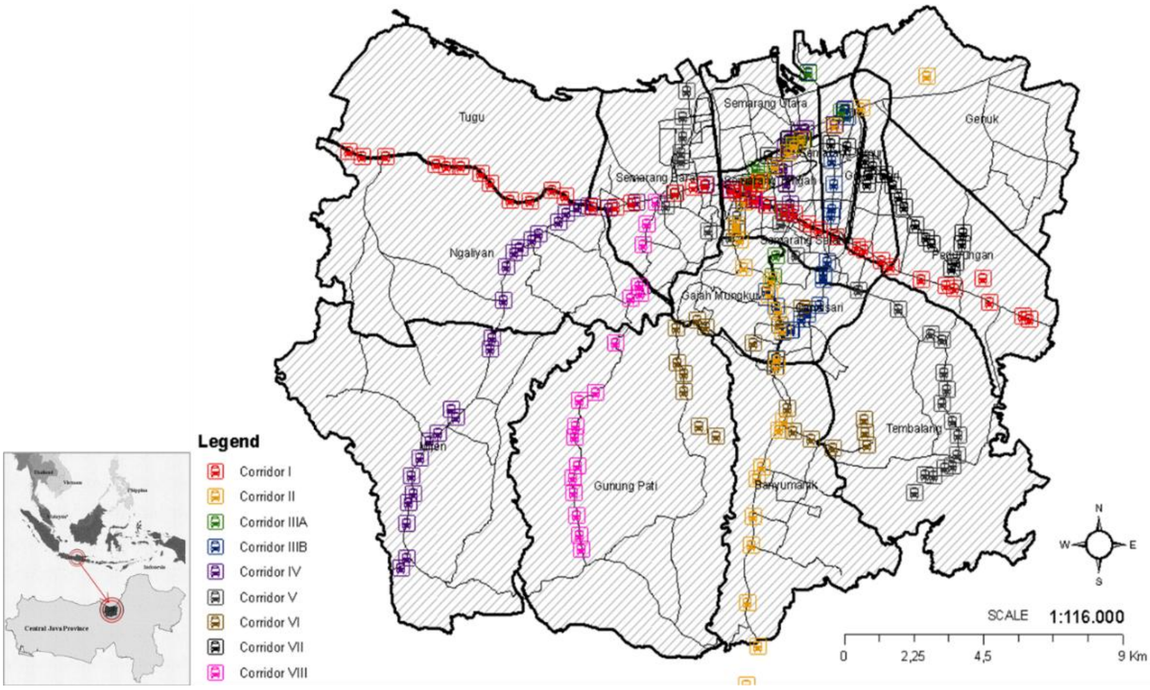


Figure 1. Bus Trans Semarang stops in the study area

The entire Bus Trans Semarang corridor in this study has 596 bus stops scattered from the city center to the suburbs and connects various important land uses such as terminals, government centers, education centers, and other land uses can be seen in Table 1. Data from the Semarang City Transportation Office in 2018 shows a significant increase in the number of Bus Trans Semarang passengers from 2010 to 2018. The total number of passengers in 2010 was 369.326 passengers to 10.210.296 passengers in 2018. The largest contributor for pedestrians in this study is Corridor I, which also has massive bus stops and fleets than the other eight corridors. Based on data from the results of field observations carried out, pedestrian activities along the Bus Trans Semarang corridor are dominated by work activities, going to or from school, and recreational activities. City center areas such as in Corridors I, II, and IV have more massive pedestrian activity than other corridors.

Table 1
Bus Trans Semarang corridor profile

Corridor	Rute	Number of			Corridor Length (Km)	Operating Years
		Pedestrian (People)	Bus (Unit)	Stops (Unit)		
I*	Mangkang Terminal→Penggaron Terminal.	2.713.852	25	81	60,0	2009
II	Terboyo Terminal→Sisemut Terminal.	838.081	34	74	26,5	2012
IIIA	Tanjung Emas Port→Kagok→Tanjung Emas Port.	166.934	16	45	10,5	2014
IIIB	Tanjung Emas Port→Elizabeth Hospital→Tanjung Emas Port.	111.289		40	10,0	2014
IV	Cangkiran Terminal →Semarang Tawang Station.	520.436	22	87	22,3	2013
V	Meteseh Residential Area→Airport→Marina Beach.	366.319	16	75	25,9	2017
VI	Diponegoro University→Semarang State University.	257.831	16	63	13,4	2017
VII	Terboyo Terminal→Semarang City Hall.	87.886	13	63	6,9	2018
VIII	Cangkiran Terminal→Simpang Lima (City Center).	56.799	20	68	22,4	2019

*Note : *corridors with the most pedestrians*

Methods

The method used in this research is a quantitative research method that focuses on analyzing the built environment in the form of density, diversity, and design. Retrieval of data for analysis needs using naturalistic observation techniques that see the research object's condition in a more real way directly to the field. Density analysis assessed population density by comparing the total population using the density interpolation method in ArcGIS 10.3. This analysis produces a spatial picture of population density in each corridor. The density component analysis also use the numerical calculation method of Floor Area Ratio (FAR) by comparing the number of buildings per floor area. The calculations by Duduta (2013), divided into three categories, that is low density, medium density, and high density as follows:

$$\text{Low density} = \frac{\text{number of buildings } 1-2 \text{ floors}}{\text{the total number of buildings within a 200 meter radius of the stop point}} \quad [1]$$

$$\text{Medium density} = \frac{\text{number of buildings } 3-8 \text{ floors}}{\text{the total number of buildings within a 200 meter radius of the stop point}} \quad [2]$$

$$\text{High density} = \frac{\text{number of buildings} > 8\,\text{floors}}{\text{the total number of buildings within a 200 meter radius of the stop point}} \quad [3]$$

Diversity components were analyzed using the land use ratio analysis by comparing the land as residential, commercial, office space, public services, and recreation to the total land area around the Bus Trans Semarang stop in each corridor. According to Sung and Choi (2013), this diversity of land uses can be explain using the balancing index (RNR index) formula by comparing non-residential land use with residential land.

$$RNRi = 1 - \left[\frac{Res - Nonres}{Res + Nonres}\right] \rightarrow \text{The closer to 1, the more balance} \quad [4]$$

Meanwhile, analyzing the design component can be done by looking at the road structure and the completeness components of pedestrian ways based on pedestrian movement needs. In this case, the assessment indicators are elements of the completeness of the crossing, ramps, the presence of intersections, the width of the pedestrian ways, the number of lanes, and pedestrian ways furniture. This component of the analysis was presented to visualize the existing conditions and compare them with the required pedestrian component demand data in Semarang. The overall results of the density, diversity, and design analysis were processed using the significance of linear regression (partial T test) using the SPSS Statistics 24 application to determine the effect of the built environment on walking activities in each corridor. Linear regression has been widely used in previous research to produce a model of the relationship between the built environment variables and pedestrian movement patterns in an area. The requirements of linear regression analysis (partial T test) are if the results of the coeficients t are greater than the t table, which is 2,353 and the significance value of the regression results data is less than 0,05 (<0,05), then there is a significant relationship between dependent and independent variables, or both variables influence each other. The built environment variable consisting of density (X1), diversity (X2), and design (X3) as independent variables is correlated with the dependent variable in the form of pedestrian intensity in each corridor (Y) can be seen in Figure 2.

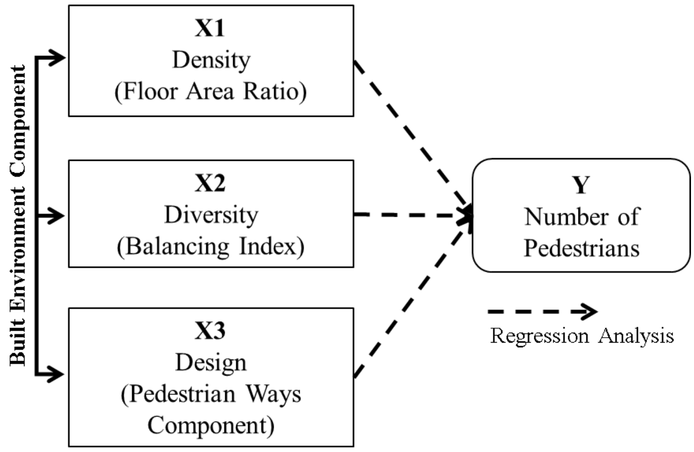


Figure 2. Linear regression analysis diagram

RESULT AND DISCUSSION

Density Analysis

Based on the calculation of the comparison between total population and land area in Semarang City, it was found that the highest population density occurred in the downtown area that can be seen on Figure 3. This is relevant to the theory of urban growth in the world which states that the closer to the city center, the higher the population density (Fee & Hartley, 2012). The high population density will increase the demand for public transportation trips such as Bus Rapid Transit, so it is necessary to increase services in areas with high density (Patankar et al., 2007). The implementation of the Bus Trans Semarang system has paid attention to this theory, as evidenced by all routes (I-VIII) that pass through the city center and the many bus stops provided that can be seen on Figure 3.

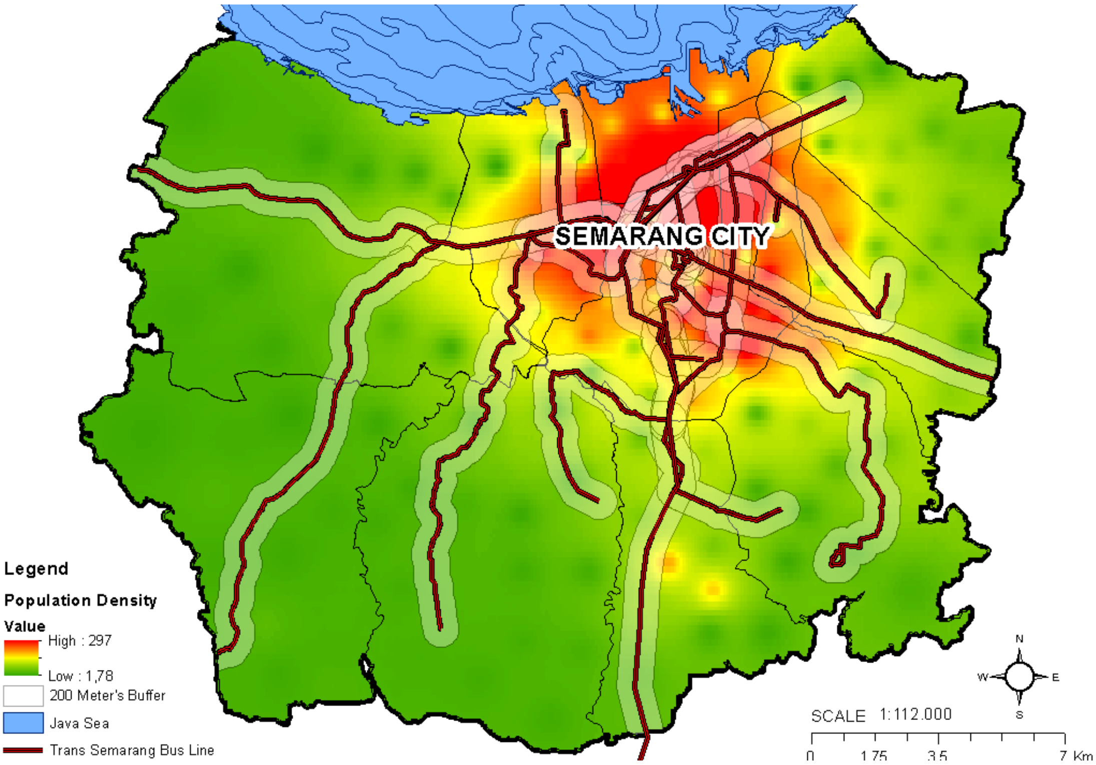


Figure 3. Population density in buffer area 200 meters from bus corridor

In addition to calculating population density, the density component can be measured by looking at the density of the building. The calculation of density values in Table 2 about condition of the element density of each corridor found that Corridor IIIB has the highest total density compared to other corridors. The density that occurs in this corridor is dominated by 1-2 floors buildings, indicated by the low-density value reaching 0,983. Data from observations show that the entire Bus Trans Semarang corridor dominated by developments in a horizontal direction following the road network. The calculations in Table 2 regarding the element density conditions for each corridor show that of the nine corridors, only three corridors have a relatively high-density value (33%).

Research on transportation hubs in Japan found that a high Floor Area Ratio (FAR) value with optimized vertical building construction improves land use quality and creates effective movement for pedestrians (Yang & Yao, 2009). Areas with high density with vertical buildings around them will minimize motorized vehicle use and increase pedestrian intensity (Cervero & Kockelman, 1997; Monteiro & Campos, 2012; Zhang et al., 2016). The density analysis results along the Bus Trans Semarang corridor is also contrary to the results of research conducted by Zhao et al. (2018), dominance of the density component's effect on the built environment on pedestrian activity in Beijing is a high-density category. In line with the Chinese government's policy of intensifying vertical development to implement a sustainable city policy. It is different from the condition of existing regulation in Semarang, which has not emphasized vertical building. There needs to be an increase in vertical building growth, especially in downtown areas where office buildings dominated to optimize land use and create a pedestrian-friendly, sustainable transit-based transportation system.

Table 2
The condition of the element density of each corridor radius 200 meters

Corridor	Building				Lenght of corridor (Km)	Large of corridor (Ha)	Total Density (unit/Ha)	Density		
	1-2 floors (unit)	3-8 floors (unit)	>8 floors (unit)	Total (unit)				Low	Medium	High
(1)	(2)	(3)	(4)	(5)	(6)	200*(6) = (7)	(5)/(7)	(2)/(5)	(3)/(5)	(4)/(5)
I	4.358	290	8	4.656	60,0	1.200	4	0,897	0,096	0,007
II	3.833	130	3	3.966	26,5	530	7	0,960	0,043	0,001
IIIA	3.258	84	6	3.348	10,5	210	16	0,958	0,039	0,003
IIIB*	6.249	85	6	6.340	10,0	200	32	0,983	0,016	0,001
IV	714	167	21	902	22,3	446	2	0,758	0,172	0,028
V	968	152	18	1138	25,9	518	2	0,817	0,164	0,039
VI	3.587	121	0	3.708	13,4	268	14	0,936	0,064	0,000
VII	654	110	2	766	6,9	138	6	0,824	0,149	0,002
VIII	171	96	7	274	22,4	448	1	0,632	0,341	0,027

*Note : *corridor with the highest density*

Diversity Analysis

The results of the equilibrium index calculation in Table 3 show that the total balance index value of all corridors is close to 1. The balance index value close to one categorized as an area with mixed land use with a high balance value (Sung & Choi, 2013). The highest balancing index value is in the Corridor II area. The result of the balancing index value in this corridor is 1,110 with the main designation as a trade and service center. Its function as a center for trade and services has made this area experience increasingly diverse land uses. The proportion of residential and non-residential land in this area is very stable, with a residential area of 60 hectares and a non-residential area of 59 hectares within a 200-meter radius from the transit center. As one of the longest corridors, Corridor I has the smallest balancing index value compared to other corridors, which is only 0,395 (getting away from 1). The proportion of residential land area with non-residential land in this corridor is in the unbalanced category. Residential land reaches 98,70 hectares, while for non-residential areas dominated by trade and services, offices, and industry, only 40,22 hectares.

Table 3
Condition element diversity for each corridor radius 200 meters

Corridor	Res (Ha)	Non-res (Ha)	Balancing Index	Landuse
	(1)	(2)	(1)/(2) = (3)	(4)
I**	98,70	40,22	0,395	Settlements, industry, trade and services, warehousing, worship, defense and security, offices, education, health, recreation, public spaces, sports.
II*	60,59	58,72	1,110	Offices, trade and services, police education and sports, industry, and housing.
IIIA	64,58	89,44	0,831	Defense and security, education, health, offices, public spaces,
IIIB	56,55	23,04	1,184	recreation, settlements, trade and services, and worship.
IV	261,32	339,46	0,870	Offices, worship, health, trade and services, education, housing, recreation, defense and security, and transportation.
V	215,86	311,21	0,820	Education, health, industry, offices, defense and security, housing, sports, recreation, trade and services, and worship.
VI	57,68	31,10	1,314	Defense and security, education, health, offices, settlements, recreation, trade and services, and worship.
VII	129,01	247,47	0,685	Education, health, industry, offices, defense and security, housing, sports, recreation, trade and services, and worship.
VIII	158,80	167,19	0,938	Trade and services, worship, health, education, offices, recreation, defense and security, and settlements.

*Note : Res (Residential area), Non-res (Non-residential area): *corridor with the highest balancing index ; **corridor with the lowestt balancing index.*

The location of the highest balancing index for Corridor I is the same as that of Corridor VIII, that is at the Amarta bus stop point that can be seen Figure 4 section h. The balancing index value at this point is 1.10, which is dominated by non-residential land use in trade and services. The locations with the highest balancing index at the Corridor II area is City Hall bus stop that can be seen in Figure 4 section a. The balancing index value at this point is 0,96 with the dominance of non-residential land use in the form of offices and educational buildings. Meanwhile, for Corridor IIIA, the location with the highest balancing index value is at the point of the Raden Patah bus stop that can be seen in Figure 4 section b. The balancing index value at this point is 1,06 with the dominance of non-residential land use in the form of trade and services and school buildings. The highest balancing index value for Corridor IIIB has located at the Don Bosco stopping point that can be seen in Figure 4 section c, with a value of 1,06. The dominance of land use in this corridor is the use of residential land in housing and school buildings.

The location with the highest balancing index value is in the Corridor IV area, that is at the Nyaliyan Square stop that can be seen in Figure 4 section d, with a value of 0,99. The dominance of land use in this corridor uses non-residential land in the form of trade and services and educational buildings. Meanwhile, based on Figure 4 section e in the Corridor V area, the highest balancing index value is at the Karang Ayu bus stop point with 1,00 (very balanced). The dominance of land use in this corridor is a land-use Settlement. The location with the highest balancing index value in Corridor VI is at the Diponegoro University Nursing stop (educational area) with a value of 1,04. Based on Figure 4 section f, it can be seen that the dominance of land use in this area is non-residential land use in the form of educational buildings. Meanwhile, for the highest balancing index, Corridor VII is located at the Petek bus stop that can be seen in Figure 4 section g. The balancing index value at this point is 0,99 with the dominance of non-residential land use in the form of trade and services.

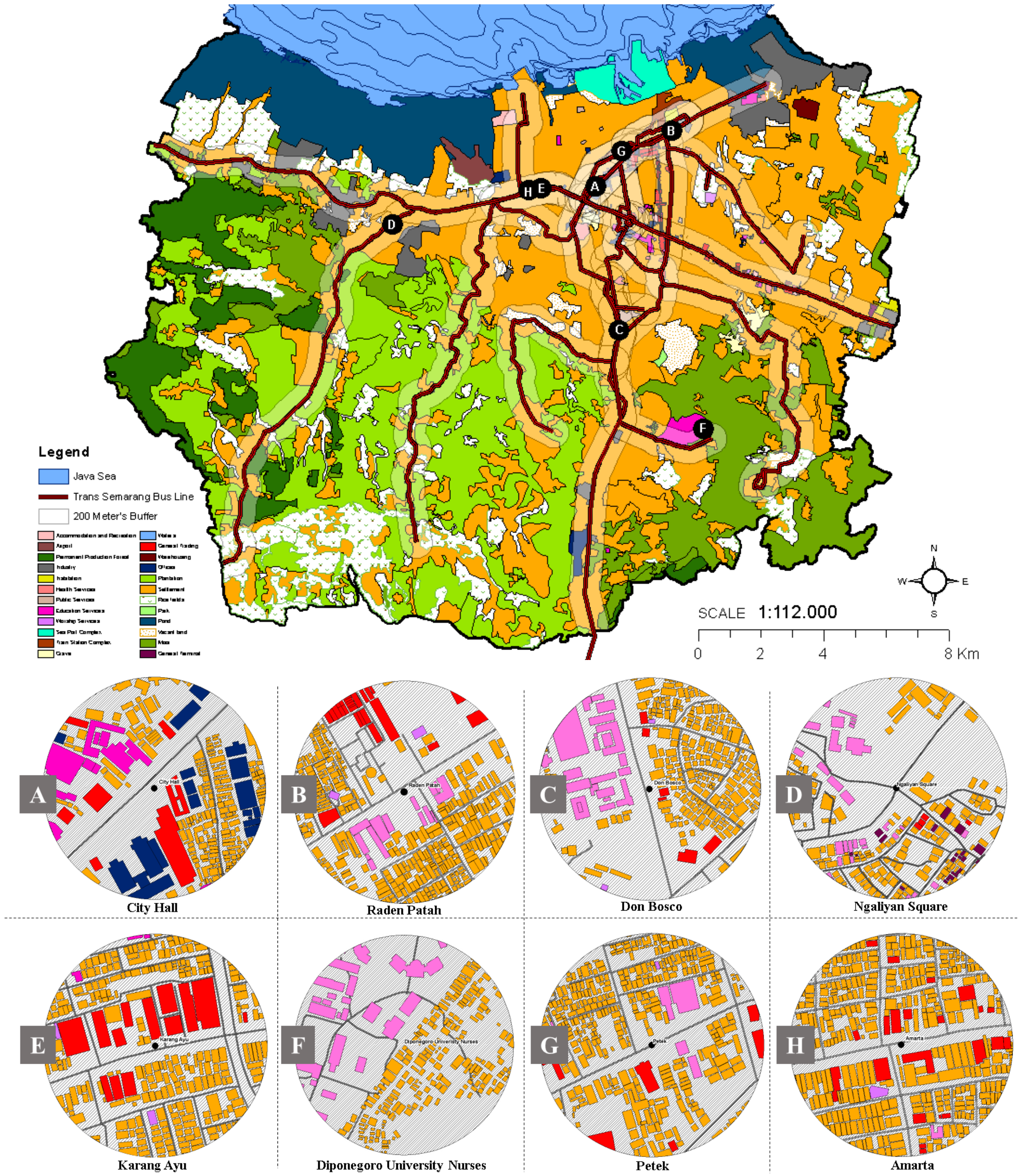


Figure 4. Land use corridor and highest balancing index value (200 meters) ; (A) Corridor II, (B) Corridor IIIA, (C) Corridor IIIB, (D) Corridor IV, (E) Corridor V, (F) Corridor VI, (G) Corridor VII, (H) Corridor I & VIII.

The diversity analysis results for all Bus Trans Semarang corridors have the same pattern as the balance index results. Locations with high equilibrium index values, dominated by land use for trade and services and education. Commercial land uses such as educational land use also trade and services land use can increase interest in walking in the area (Miranda-Morenoa et al., 2011; Townsend & Zacharias, 2010; Chalermpong, 2007). Based on field observations, activities in the area of trade and services also education are only active in the morning and evening, especially on weekdays (Monday-Friday), so that pedestrian ways traversed outside this time. There needs to be an increase in attractions to bring in activities so that public facilities such as pedestrian ways can function optimally. Areas with mixed land use characteristics on foot will be more attractive because the resulting movements are more diverse (Untermann et al., 1984). So that various types of land use are needed to improve population activities' pattern to optimize land use and create a sustainable pedestrian system.

Design Analysis

Based on the pedestrian way design analysis, the results show that Corridors IV, I, and II are corridors with the largest number of inclines, crossings, and irregularities compared to other corridors, it can be seen in Table 4. Compared with the pedestrian data in Table 1, a linear pattern is seen. Corridors with the highest number of pedestrians tend to have more complete pedestrian facilities. Another indication is that the closer to the city center with a denser population activity level, the better and more complete the pedestrian ways design will be. Some locations in areas far from the city center that are traversed by Corridor VI only have pedestrian ways with a width of 1-2 meters and are only equipped with vegetation, shown in Figure 5.

Table 4

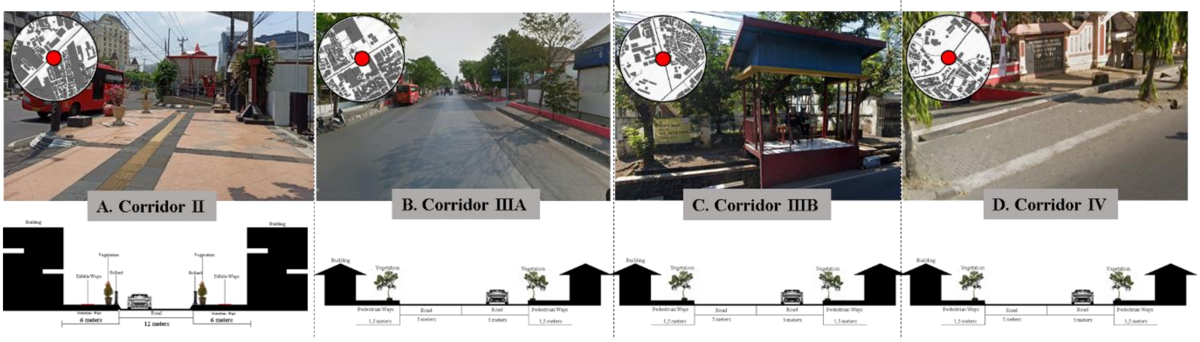
Complete pedestrian ways design for the Bus Trans Semarang corridor radius 200 meters

Corridor	Pedestrian Ways Large (m)	Lanes of the road	Number of			Street Furniture
			Inter sections	Ramp	Crossings	
I*	1-5	2 – 6	172	267	42	Shade vegetation, bollards, lights, trash cans, traffic signs, seats, special lanes for the disabled.
II*	1-5	2	165	138	38	Traffic signs (no stopping sign, no parking), street lights, ways with disabilities, and potted vegetation.
IIIA	1-5	1 - 2	95	3	13	Lights, bollards, vegetation, traffic signs, trash cans, fire hydrants.
IIIB	1-1,5	1 - 2	246	0	22	Shade vegetation, and traffic signs.

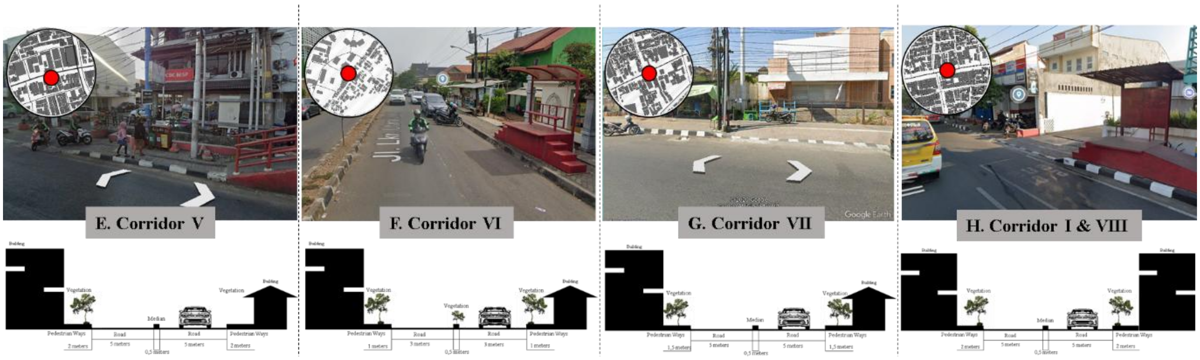
Corridor	Pedestrian Ways Large (m)	Lanes of the road	Number of			Street Furniture
			Inter sections	Ramp	Crossings	
IV*	1-3	2 - 4	110	396	30	Shade vegetation, bollards, lights, traffic signs, and special lanes for the disabled.
V	0,5-2,5	1 - 2	170	27	31	Shade vegetation, lights, traffic signs, benches, and special lanes for people with disabilities.
VI	1-3	2	132	40	18	Traffic lights and signs.
VII	1-2,5	1 - 2	127	21	12	Shade vegetation, lights, traffic signs, and ways for the disabled.
VIII	1-3	2 - 6	24	184	16	Shade vegetation, special lanes for people with disabilities, and traffic signs.

Note : corridor with the most complete design elements

The sidewalks along the Bus Trans Semarang corridor still need improvement because there is still a gap between the current condition and user expectations. The region's undulating topography and climatic conditions mean that the average walking distance in Semarang City is only 200-250 meters. Completeness design components and city environmental conditions of pedestrian ways can increase people's tendency to walk to a destination (Özbil et al., 2015). Completeness of pedestrian ways such as ramps, pedestrian ways, vegetation, and others can affect walking activities when working or not working (Dixon, 1996; Munshi, 2016). Also, as a country with a tropical climate with year-round sunshine, it will impact the lack of comfort in outdoor activities such as walking. There is a need for climate adjustment by providing vegetation as shade as applied to four-season countries such as Montreal, Canada (Miranda-Morenoa, 2011). Therefore, it is necessary to have a pedestrian way with complete facilities and pay attention to environmental and climatic conditions to realize a sustainable transportation system.



(a) Sample of pedestrian ways ; corridor II, corridor IIIA, corridor IIIB, dan corridor IV.



(b) Sample of pedestrian ways ; corridor V, corridor VI, corridor VII, and corridor VIII.
Figure 5. Pedestrian ways conditions throughout the Bus Trans Semarang corridor

Built Environment Influence Model on Pedestrians

Based on the linear regression test results using the partial coeficient T test method to determine the significance of the relationship between two or more variables. Two things can be used as benchmarks in this method, that is the coeficient T results and the significant results. The dependent variable is the number of pedestrians passengers of the Bus Trans Semarang per corridor (Y), and the independent variable is a built environment component consisting of the total density (X1), balancing index diversity (X2), and the number of pedestrian way design elements (X3), a radius of 200 meters. Based on Table 5 about the results of linear regression data processing (coeficient T test), which obtained coeficient T value of variable density (X1) of 0,454 and a significance value of 0,669 (>0,05). This means that the density-independent variable (X1) does not significantly influence the dependent variable pedestrian intensity (Y) because of the calculated T value < T table 2,353and the significance value is greater than 0,05.

Based on the same table, it shows that the independent variable diversity (X2) has an coeficient T value of 7,028 (> 2,353) and a significance calculated value of 0,001 (<0,05), which indicates a significant relationship between the dependent variable pedestrian intensity. (Y) with the independent variable diversity (X2). The independent variable in the form of diversity can affect the intensity of pedestrians at the research location, with the direction of the positive influence, that is the more balanced land use in an area, the more a person's desire to walk. Based on the same table, it shows that the independent variable design (X3) does not have a significant relationship with the dependent variable pedestrian intensity (Y). This is because this variable has an T calculated value of 1,624 which is smaller than T table 2,353 and the results of the calculation of significance are greater than the standard of tolerance of 0,05.

Table 5

The results of data processing linear regression (partial T test) SPSS

Code	Independent Variable	T*	Sig**
X1	Density (Floor Area Ratio calculation results)	0,454	0,669
X2	Diversity (The ratio of residential and non-residential land or Balancing Index)	7,028	0,001
X3	Design (The completeness of the pedestrian ways elements)	1,624	0,165

*Note : The F table value is 2,353: *If T count> T the data table has a close relationship; **Sig <0,05 has a significant relationship meaning.*

The results of the model of the influence of the built environment on pedestrian activity in Semarang are relevant to research conducted in the City of Montreal, Canada. The results suggest that land diversity can influence a person's tendency to walk uses around the transit center (Miranda-Morenoa et al., 2011). Similar to the research results in the city of Semarang, land use as a center for trade and services and school buildings dominates the goals of pedestrian movement in the City of Montreal, Canada. Likewise, the research results in Bangkok, the use of commercial land, tends to encourage someone to walk around transit centers (Townsend & Zacharias, 2010; Chalermpong, 2007). The environmental conditions along the transit-based transportation routes in Bangkok City have the closest characteristics to this research. The characteristics of building density and land use are relatively spread out, from the city center to the suburbs. Another similarity is that the pedestrian ways are not optimal. The difference between the study results and previous research lies in the coverage of the research area, topographical conditions, and urban development policies. Montreal and Beijing China's Canadian city tends to influence the density component on a person's wouldingness to walk because of the flat topography, the relatively close distance between buildings and transit centers, and supporting vertical development policies. Also, the pedestrian design elements in this area are relatively complete when compared to Semarang City and Bangkok City of Thailand. The following is a diagram of the resulting model in Figure 6.

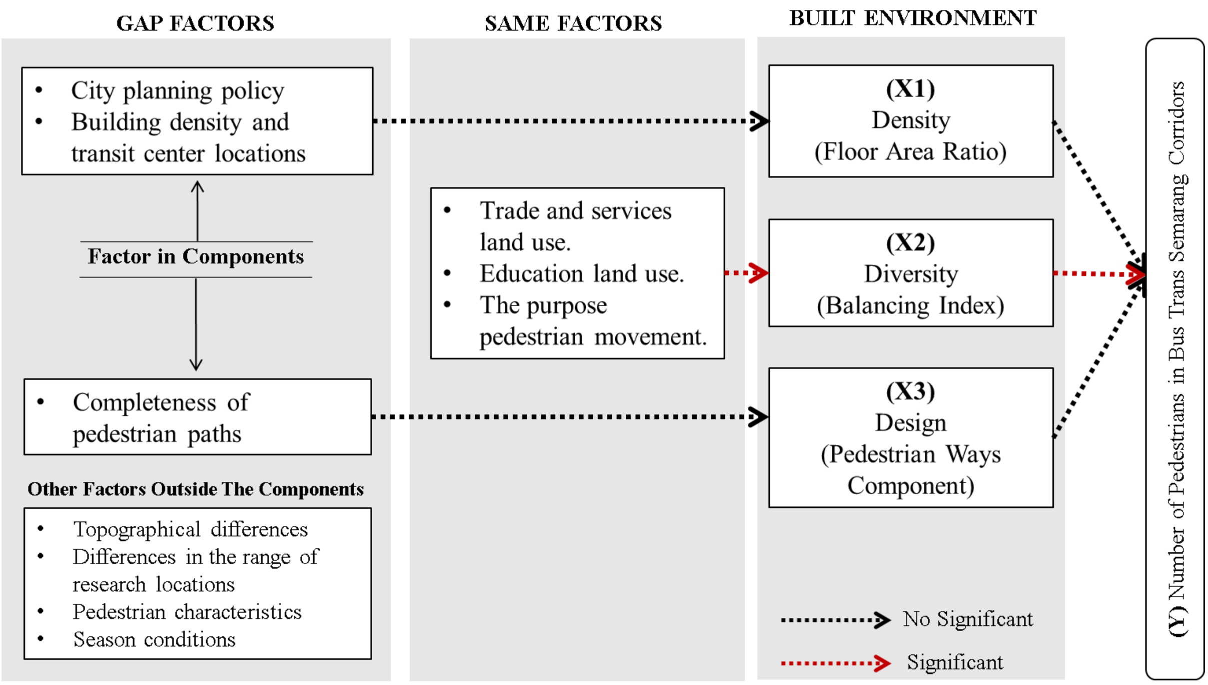


Figure 6. Model diagram analysis influence of the built environment and pedestrian activity.

CONCLUSION

The analysis results show that the diversity component is a component of the built environment, which significantly influences people's desire to walk along with the Bus Trans Semarang. Diversity conditions around pedestrian ways in Semarang City show a high balancing index between residential and non-residential land uses. The domination of commercial land use is in the form of trade and service areas, and also education. High mixed land use areas will tend to affect people's willingness to walk because the resulting activity patterns are more diverse.

Meanwhile, two other components, such as density and design, have not influenced a person's desire to walk. Because the optimization of vertical development is still very minimal, the distance between buildings tends to be far apart. The lack of availability of pedestrian facilities along the Bus Trans Semarang corridor, especially in the city center area, is also why these two built environment components have not been able to influence the desire to walk in the city of Semarang. It is feared that this will also affect a person's willingness to use transit-based transportation, such as the Bus Trans Semarang. So it is hoped that there is a need for follow-up in adjusting pedestrians' needs with the built environment along the Bus Trans Semarang corridor to create a sustainable transportation system.

ACKNOWLEDGEMENTS

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The Built Environment and Its Impact on Transit Based Transportation User Walking Activities in Semarang, Indonesia.

The Built Environment and Its Impact on Transit Based Transportation Users Walking Activity in Semarang, Indonesia.

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ABSTRACT

Currently, an increase in population with a rising need for mobility, has become a challenge in urban development. The pedestrian walkways that are integrated with transit centers based-transportation has been developed, to minimize problems due to the high level of mobility of the urban population. Some experts say that environmental conditions are one of the main factors that can affect the frequency of pedestrians. This study aims to explore the affect of the built environment (such as density, diversity, and design), on the pedestrian frequency of the Bus Trans Semarang passengers. The research data collection was carried out on 9 corridors, consisting of 447 bus stops, directly connected to the pedestrian walkways, as feeder for transit-based transportation facilities. The analysis method used for each variable was the formulation technique and data simulation, using applications, such as ArcGIS, with the linear regression partial t-test model, as well as determining the effect of pedestrian frequency (Y), and the built environment elements (X). The results showed a positive significant influence between the diversity variable, and increase in the frequency of pedestrians, along the Bus Trans Semarang corridors. Furthermore, the land that varies with the dominance of commercial and educational area, has the highest attraction features that affects a person's desire to walk. Therefore, the more the lands are diverted to various uses in an area, the increase in attraction, leading to the different activities carried out during walking.

KEYWORDS

Built Environment, Transit Based Transportation, Pedestrian Walkways.

INTRODUCTION

The development of a transit-based system is carried out intensively, as an alternative method to overcoming population growth and private transportation, in various Asian countries. The Asian region is generally known for its unhealthy transportation system, which causes various problems, such as congestion, air pollution, and sprawl issues (Makarova et al., 2017). In order to overcome this, the World Health Organization (WHO), encouraged countries to implement sustainable transportation systems, that focuses on safe, efficient, accessible, affordable, inclusive, green, and healthy transportational mobility.

A Transit-Oriented Development (TOD) is a form of sustainable transportation, that emphasizes on integrating urban spatial design, to unite people, activities, buildings, and public spaces, through connectivity, which is accessible by walking (Institute for Transportation & Development Policy, 2017). Increasing walking intensity (walkability), is considered as part of the effective solutions in overcoming unhealthy transportation, because it minimizes congestion, increases environmental sustainability, encourages physical activity, improves public health, and enhances the appropriateness of urban settlements (Blanco & Alberti, 2009). The pedestrian walkways, commonly referred to as a sidewalk in a transit-based transportation system, is a facility feeder, connecting a transit centre in the form of a stop with other activity functions in its surrounding area (Hu et al., 2013). However, the lack of optimal pedestrian walkways, is a challenge for establishing a sustainable transportation system in several countries.

Various studies suggested that, the optimization of pedestrian walkways, such as the completeness of design components, an attractive, safe, and comfortable city shape can increase residents' tendency in walking to a destination (Özbil et al., 2015). Also, changes in the built environment, such as land-use planning and urban design, are crucial in increasing pedestrian activity in cities (Timmermans, 2009). However, research on the relationship between the conditions of the built environment, and walking tendency in the transit-based transportation system, is still rare. Furthermore, various parties have been inclined to focus on the opportunity to increase the transportation system provisions, without observing how the developments that occur affect the environment. Therefore, the development of a new transportation system is observed to be linear, with the uneven distribution of building density and land-use management, resulting in several pedestrian walkways not functioning properly.

The developing environment in the transit-based transportation system, commonly found in Europa region countries. The initial milestone in the research on the built environment, was first carried out by Cervero, in the European region, as an agenda to welcome the new urbanism concept. In assessing the built environment from the same source, three main components were the author formulated, namely, density, diversity, and design. The density is defined as the component produced by observing population frequency, per household and building quality per area (Cervero & Kockelman, 1997; Monteiro & Campos, 2012; Zhang et al., 2016). Furthermore, the research on the built environment and pedestrian activity in previous studies, observed that the areas with high level of density, had more influence on the walking intensity of people (Oktaviani et al., 2020). The diversity component is represented as a land-use balancing index by comparing the ratio of residential and non-residential (commercial) land use. As the level of balancing land-use in an area rises, the activities of pedestrians begins to increase (Sung & Choi, 2013). The design component is part of the features referring to the assessment of pedestrian walkways, and its integration with the road network system (Dixon, 1996; Munshi, 2016). Moreover, the pedestrian walkway design attribute, has less effect than the other two variables, because it is necessary to relate to the surrounding demographic conditions, and land-use diversity (Cervero & Kockelman, 1997).

Along with the development of science, assessing the components of the built environment, is also increasingly diverse. A study conducted by Duduta (2013), developed indicators for assessing density components, in the form of constructing measurements, which are well related to building height or the Floor Area Ratio (FAR) analysis method. The study, takes a minimum distance of 200m from the stop point was recorded, and divided into three categories of level assessment, i.e., low (1-2 floors), medium (3-8 floors), and high (>8 floors) densities. Furthermore, simplifying the research of Cervero and Kockelman (1997), the diversity component emphasizes on the calculation model of residential and non-residential land area ratios, which in this case, is measured by the balancing index formula (Sung & Choi, 2013).

However, the design component's measurement is more complex than that of the other two (density & diversity), with a system of assessing the elements of pedestrian walkway completeness, adjusted to environmental conditions (Zhang et al., 2016). This study summarized the design indicators needed to identify the appropriate pedestrian walkways at the research location. The includes the lane width, route count, road intersection number, the presence of ramps, bridges, and zebra crossings, as well as the completeness of street furniture. The country context has an essential role in ascertaining the built environment assessment of pedestrian activities. The biggest question emerging from previous research, is based on whether the context of the built environment in the European region remains the same as that in the Asian zone.

Furthermore, a research in downtown Montreal, Canada showed that, the components of the built environment, density (population, number of jobs, schools, and bus stops), diversity (commercial land use), and design (percentage of main arteries, average length of roads), affects pedestrian activity (Miranda-Morenoa et al., 2011). This city's position in Canada State, is a provincial capital, which is not included in the national central area, and is observed to be a part of the cities located in developed countries. The problem encountered in the provision of pedestrian walkways in this area, is the lack of walkers' security. This area has a complete pedestrian walkway element, with skyscrapers all around it. As a four-season country, the provision of vegetation along the pedestrian walkways in the city, is designed to suit seasonal conditions, because the designs that adapt to climate change and periods, are being intensified, in a bid to create sustainable urban life.

The discussion of the built environment, on pedestrian walkways in developing countries, for example the transit area in Bangkok, Thailand, obtained results in the form of an interplay, between people's tendency to walk, and the diversity of land-use around the transit area (Townsend & Zacharias, 2010). The walkway condition in Bangkok, Thailand, is confronted with air pollution and lack of sidewalks (Townsend & Zacharias, 2010; Chalermpong, 2007). From the study, the development of commercial, retail, and residential land is relatively high around the transit centre, which shows that, the influence of diversity is high enough on pedestrian movement patterns.

Furthermore, the research conducted in other Asian regions, such as Beijing, China, obtained different results. The findings on the built environment, at the environmental-scale transit centres in Beijing, showed that, the density component plays a substantial role in influencing pedestrian activities (Zhao et al., 2018). In that study, the pedestrian walkway components in this country, is complete compared to the provision in Bangkok. Also, the influence of the vertical building construction policy in the central area of Beijing City, is the basis for the formation of a compact province, with relatively close distances between buildings. The density of the built environment in this area, influences a person's inclination to walk. Therefore, the geographic characteristics with scope of the research conducted in Bangkok and Beijing, are relatively the same, because it is often carried out in areas with relatively flat homogeneous topography, with environmental scale research coverage.

Semarang is one of the major cities in Indonesia, which is located in Central Java Province. The city, with a total population of 1.79million people, plans to develop a Transit Oriented Development (TOD) system, to accommodate the mobility needs of the community, and create a sustainable transportation channel. Furthermore, a part of the requirements needed for the development of the TOD system in Semarang City, is the Bus Trans Semarang. Observation of the relationship between the built environment and pedestrian activities in the central transit area, along the Bus Trans Semarang corridor, seems interesting, because, it covers the city centre area and its surroundings has a flat to undulating topography. The problem of pedestrian walkways provision in Semarang City, is the same as that of Bangkok, i.e., pollution issues, and lack of sidewalks. Based on further data, it was observed that, about 88% of Bus Trans Semarang passengers, walked to and from within bus stops (Purwanto & Manullang, 2018). This result is certainly in contrast to the lack of pedestrian walkways provision in the city of Semarang, which then causes a gap between acquisition and demand. Policies regarding land-use, regulated by City Territory Section (CTS), observed that, the use of land in Semarang City is very diverse.

The absence of a firm policy on building construction efforts, has resulted in a high sprawl level in this area. Therefore, this study aims to ascertain the best built environment model, that affects a person's tendency to walk along the Bus Trans Semarang corridor, from the city centre to the suburbs. This is further accompanied with a research question, in the form of, Do the built environment components affect the pedestrian activity of transit-based transportation users in Semarang City?.

STUDY METHODOLOGY

Semarang Study Area

Semarang City is one of the metropolitan cities in Indonesia, located in Central Java Province, with a population of 1.79million. According to the data obtained from the Semarang City Statistics Centre in 2019, the population of the area keeps increasing by 50% yearly, accompanied by the provision of a public transportation system, which is not yet optimal. This location is one of the pilot areas for Bus Rapid Transit (BRT) development in Indonesia, with the provision of Bus Trans Semarang in 2009, to help improve the quality of transportation system (SuaraMerdeka, 2015). The undulating topography, with the uneven distribution of pedestrian walkways along the Bus Trans Semarang corridor, is interesting to study. The location in this study covers all Bus Trans Semarang routes, consisting of, Corridors I, II, IIIA, IIIB, IV, V, VI, VII, and VIII, as shown in Figure 1. According to Kim et al. (2018), there are two methods to measure the built environment, based on the area's scope, i.e., the street level of 50m, and the neighborhood position at a maximum radius of 400m, from the observation point. The data showed that the maximum distance for walking in Semarang City, is only 200m-250m between destination locations (Purwanto & Manullang, 2018). Therefore, sampling of the observation area, by using the neighbourhood level method, with a radius of 200m from the right and left of the road was carried out.

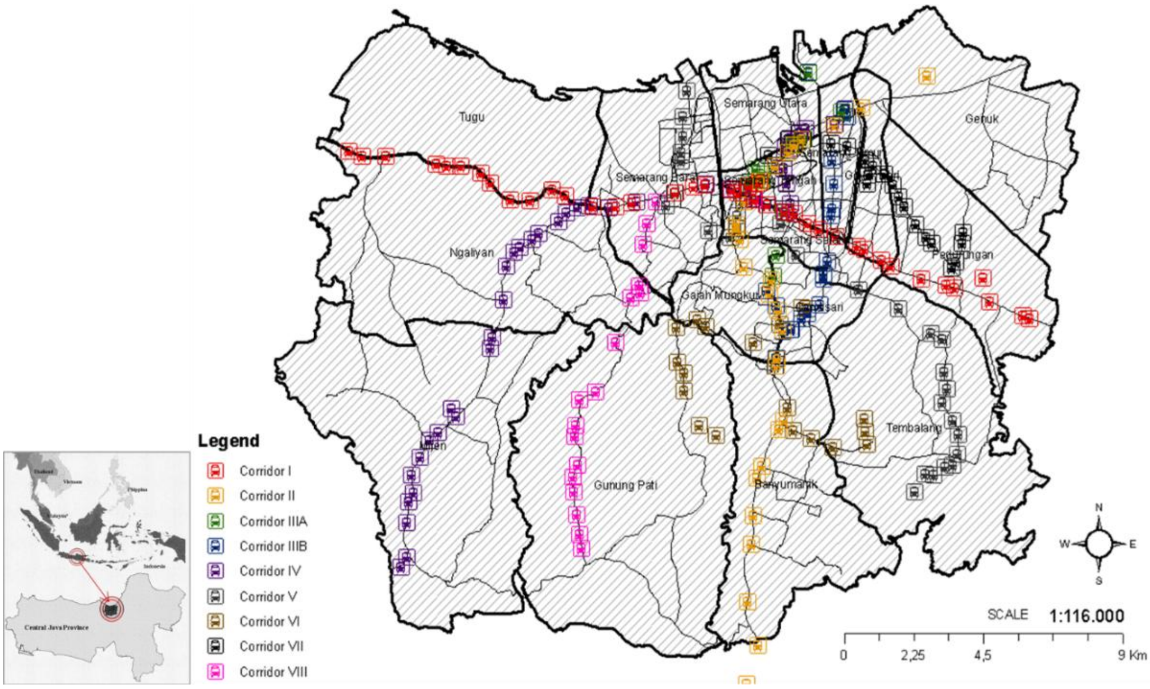


Figure 1. Bus Trans Semarang stops in the study area

In this study, the entire Bus Trans Semarang corridor has 596 bus-stops, scattered from the city centre to the suburbs, while also connecting various important land-uses, such as, terminals, government areas, education fields, and many more, as shown in Table 1. Data from the Semarang City Transportation Office in 2018, showed a significant increase in the number of Bus Trans Semarang passengers, from 2010-2018. The total number of passengers between 2010 and 2018, were 369,326 and 10,210,296, respectively. Furthermore, the largest contributor for pedestrians in this study, was Corridor I, which had massive bus-stops and fleets, compared to the other eight. Based on the data collected from the field observations, pedestrian activities along the Bus Trans Semarang corridor were dominated by school, work, and recreational activities. City centre areas such as, Corridors I, II, and IV, had more massive pedestrian activities, than other zones.

Table 1
Bus Trans Semarang corridor profile

Corridor	Rute	Number of			Corridor Length (Km)	Operating Years
		Pedestrian (People)	Bus (Unit)	Stops (Unit)		
I*	Mangkang Terminal→Penggaron Terminal.	2,713,852	25	81	60.0	2009
II	Terboyo Terminal→Sisemut Terminal.	838,081	34	74	26.5	2012
IIIA	Tanjung Emas Port→Kagok→Tanjung Emas Port.	166,934	16	45	10.5	2014
IIIB	Tanjung Emas Port→Elizabeth Hospital→Tanjung Emas Port.	111,289		40	10.0	2014
IV	Cangkiran Terminal →Semarang Tawang Station.	520,436	22	87	22.3	2013
V	Meteseh Residential Area→Airport→Marina Beach.	366,319	16	75	25.9	2017
VI	Diponegoro University→Semarang State University.	257,831	16	63	13.4	2017
VII	Terboyo Terminal→Semarang City Hall.	87,886	13	63	6.9	2018
VIII	Cangkiran Terminal→Simpang Lima (City Center).	56,799	20	68	22.4	2019

*Note : *corridors with the most pedestrians*

Quantitative Analysis

The method used in this study, was a quantitative research technique, which focuses on analyzing the built environment, in the form of, density, diversity, and design. The retrieval of data for analysis was carried out, using naturalistic observation methods, which observed the research object's condition in a more realistic means, directly to the field. Furthermore, density analysis assessed population frequency, by comparing the total populace, using the interpolation method (ArcGIS 10.3). This analysis produced a spatial picture of population density in each corridor. Also, the density component analysis used numerical calculation method, Floor Area Ratio (FAR), by comparing the number of buildings per floor area. The calculations by Duduta (2013), was divided into three categories, namely, low (equ 1), medium (equ 2), and high (equ 3) densities, as follows,

$$\text{Low density} = \frac{\text{number of buildings } 1-2 \text{ floors}}{\text{the total number of buildings within a 200 meter radius of the stop point}} \quad [1]$$

$$\text{Medium density} = \frac{\text{number of buildings } 3-8 \text{ floors}}{\text{the total number of buildings within a 200 meter radius of the stop point}} \quad [2]$$

$$\text{High density} = \frac{\text{number of buildings} > 8 \text{ floors}}{\text{the total number of buildings within a 200 meter radius of the stop point}} \quad [3]$$

Diversity components were analyzed, using the land-use ratio analysis, while comparing the land (residential, commercial, office space, public services, and recreational), to the total space area, around the Bus Trans Semarang bus-stop, in each corridor. According to Sung and Choi (2013), this diversity of land-uses were explained, by using the balancing index (RNR) formula (equ 4), to compare residential and non-residential land-use.

$$RNRi = 1 - \left[\frac{Res - Nonres}{Res + Nonres}\right] \rightarrow \text{The closer to 1, the more balance} \quad [4]$$

Furthermore, analyzing the design component was carried out, by looking at the road structure and the completeness features of pedestrian walkways, based on movement needs. In this case, the assessment indicators were the elements of completeness, which includes, crossings, ramps, intersections, lane width, number of routes, and sidewalk furnitures. The analysis of this component was presented, to visualize the existing conditions, and compare them with the required pedestrian feature demand data, in Semarang. The overall results of the density, diversity, and design analysis, were processed, using the significance of linear regression (partial T-test) and the SPSS Statistics 24 application, to determine the effect of the built environment on walking activities, in each corridor. The model formula, used in determining the influence between variables, is shown in Equation 5 below.

$$Y = a + b(X) \quad [5]$$

Where;

Y = frequency of pedestrians (person)

a = constant

b = coefficient

X = built environment variables

Linear regression had been widely used in previous researches, to produce a relationship model, between the built environment variables and pedestrian movement patterns in an area. The requirements of linear regression analysis (partial T-test) is that, when the results of the coeficients (t) are greater than the t-table (2.35), with the significance value of the regression data less than 0.05 (<0.05), then it is confirmed that both variables (dependent & independent), influences each other. The built environment variable consisting of, density (X1), diversity (X2), and design (X3) as independent variables, correlates with the pedestrian intensity in each corridor (Y), as shown in Figure 2.

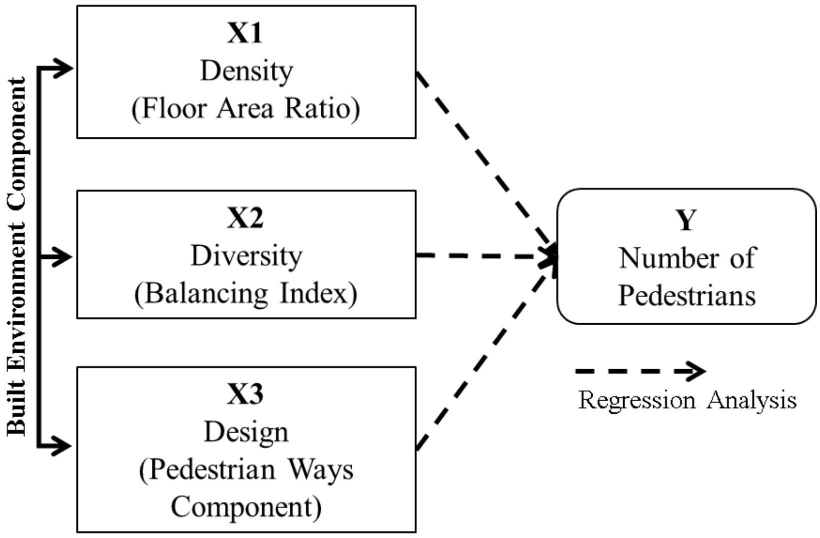


Figure 2. Linear regression analysis diagram

RESULT AND DISCUSSION

Density Analysis

Based on the comparative calculation between total population and land area in Semarang City, it was observed that, the highest populace density occurred in the downtown vicinity, as shown in Figure 3. This is similar to the theory of urban growth in the world, which states that, the closer to the city centre, the higher the population density (Fee & Hartley, 2012). The high population density increases the demand for public transportation trips, such as, BRT, therefore, confirming the necessity to integrate services in areas with high density (Patankar et al., 2007). Furthermore, the implementation of the Bus Trans Semarang system has paid attention to this theory, as observed by all routes (I-VIII) passing through the city centre and the many bus-stops provided, as shown in Figure 3.

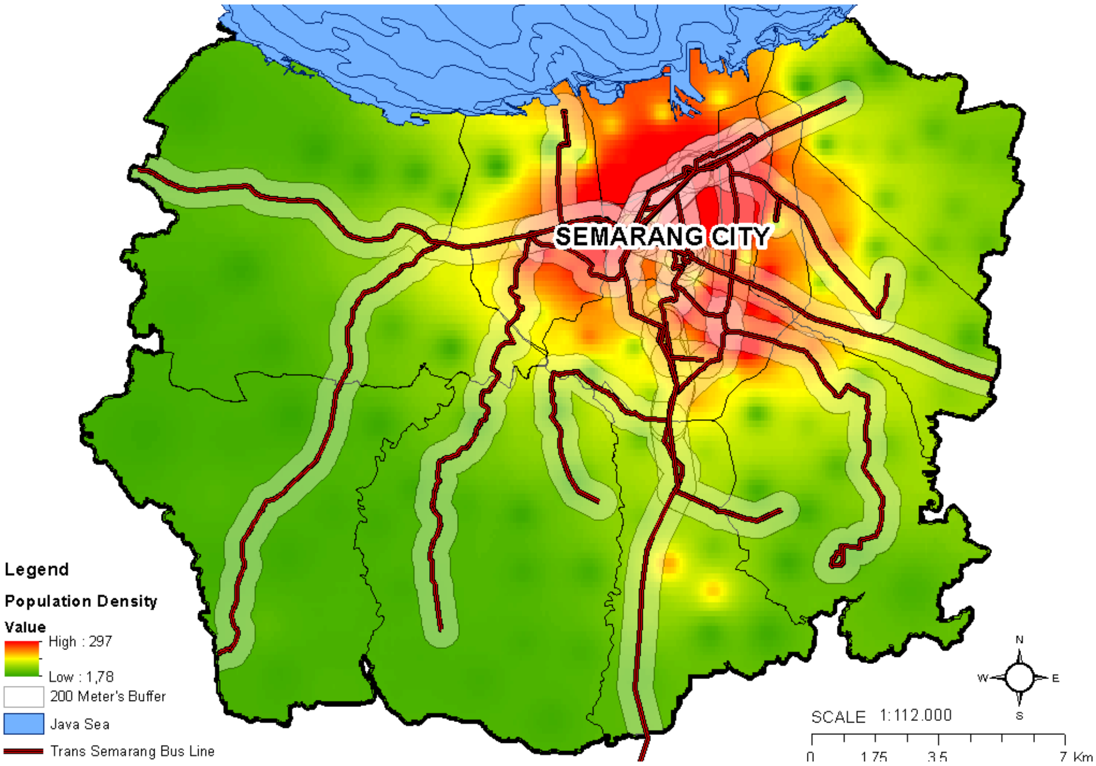


Figure 3. Population density in buffer area 200 meters from bus corridor

In addition to calculating population density, the component was measured, by observing the quality of the building. The calculation of density values in Table 2, about the condition of each corridor's element frequency, indicated that, path IIIB had the highest total, compared to other routes. The density that occurred in this corridor was dominated by 1-2 floors buildings, indicated by the low frequency value at 0.983. Data from the observations showed that, the entire Bus Trans Semarang corridor were dominated by developments in a horizontal direction, while following the road network. The calculations in Table 2, regarding the element density conditions for each corridor showed that, out of the nine routes, only three had a relatively high frequency value (33%).

Furthermore, the research on transportation hubs in Japan observed that, a high Floor Area Ratio (FAR) value, with optimized vertical building construction, improves land-use quality, while creating effective movement for pedestrians (Yang & Yao, 2009). High density areas with vertical buildings around them, minimized the use of motorized vehicle, and increased pedestrian intensity (Cervero & Kockelman, 1997; Monteiro & Campos, 2012; Zhang et al., 2016). Also, the density analysis results along the Bus Trans Semarang corridor, was contrary to that of the research conducted by Zhao et al. (2018), which stated that, the dominance of density effect on the built environment and pedestrian activity in Beijing, belonged to a high category. This was in line with the Chinese government's policy of intensifying vertical development, to implement a sustainable city policy. This is different from the condition of existing regulation in Semarang, which has not emphasized on vertical building. However, an increase in vertical building growth is needed, especially in downtown areas, as regards the optimization of land-use, with the creation of a pedestrian-friendly, and sustainable transit-based transportation system.

Table 2

The condition of the element density of each corridor radius 200 meters

Corridor	Building				Lenght of corridor (Km)	Large of corridor (Ha)	Total Density (unit/Ha)	Density		
	1-2 floors (unit)	3-8 floors (unit)	>8 floors (unit)	Total (unit)				Low	Medium	High
(1)	(2)	(3)	(4)	(5)	(6)	200*(6) = (7)	(5)/(7)	(2)/(5)	(3)/(5)	(4)/(5)
I	4,358	290	8	4,656	60.0	1,200	4	0.897	0.096	0.007
II	3,833	130	3	3,966	26.5	530	7	0.960	0.043	0.001
IIIA	3,258	84	6	3,348	10.5	210	16	0.958	0.039	0.003
IIIB*	6,249	85	6	6,340	10.0	200	32	0.983	0.016	0.001
IV	714	167	21	902	22.3	446	2	0.758	0.172	0.028
V	968	152	18	1,138	25.9	518	2	0.817	0.164	0.039
VI	3,587	121	0	3,708	13.4	268	14	0.936	0.064	0.000
VII	654	110	2	766	6.9	138	6	0.824	0.149	0.002
VIII	171	96	7	274	22.4	448	1	0.632	0.341	0.027

*Note : *corridor with the highest density*

Diversity Analysis

The results of the equilibrium calculation in Table 3 showed that, the total balance index value of all the corridors is close to 1. The balance index value close to 1, was categorized as an area with mixed land-use, possessing high parameters (Sung & Choi, 2013). The highest balancing index value, was in the Corridor II area. The result of the balancing index value in this corridor was 1.110, with trade and service centre as the main designation. Its function as a centre for trade and services, has made this area experience increasingly diverse land-uses. The proportion of residential (60 hectares) and non-residential (59 hectares) land in this area is very stable, within a 200m radius from the transit centre. As one of the longest routes, Corridor I had the smallest balancing index value compared to others, which is only 0.395 (getting away from 1). The proportion of residential with non-residential land area in this corridor, is in the unbalanced category. Therefore, residential land reaches 98.70ha, while non-residential areas dominated by trade and services, offices, and industry, only had 40.22ha.

Table 3

Condition element diversity for each corridor radius 200 meters

Corridor	Res (Ha)	Non-res (Ha)	Balancing Index	Landuse
	(1)	(2)	(1)/(2) = (3)	(4)
I**	98.70	40.22	0.395	Settlements, industry, trade and services, warehousing, worship, defense and security, offices, education, health, recreation, public spaces, sports.
II*	60.59	58.72	1.110	Offices, trade and services, police education and sports, industry, and housing.
IIIA	64.58	89.44	0.831	Defense and security, education, health, offices, public spaces,
IIIB	56.55	23.04	1.184	recreation, settlements, trade and services, and worship.
IV	261.32	339.46	0.870	Offices, worship, health, trade and services, education, housing, recreation, defense and security, and transportation.
V	215.86	311.21	0.820	Education, health, industry, offices, defense and security, housing, sports, recreation, trade and services, and worship.
VI	57.68	31.10	1.314	Defense and security, education, health, offices, settlements, recreation, trade and services, and worship.
VII	129.01	247.47	0.685	Education, health, industry, offices, defense and security, housing, sports, recreation, trade and services, and worship.
VIII	158.80	167.19	0.938	Trade and services, worship, health, education, offices, recreation, defense and security, and settlements.

*Note : Res (Rsidential area), Non-res (Non-residential area): *corridor with the highest balancing index ; **corridor with the lowestt balancing index.*

The location of the highest balancing index for Corridor I, is the same as that of VIII, i.e., at the Amarta bus-stop point, as shown in Figure 5, section h. The balancing index value at this point is 1.10, which is dominated by non-residential land-use, as trade and services. The locations with the highest balancing index at the Corridor II area, is the City Hall bus-stop, which is shiwn in Figure 5, section a. The balancing index value at this point is 0.96, with the dominance of non-residential land-use in the form of, offices and educational buildings. However, for Corridor IIIA, the location with the highest balancing index value, is at the point of the Raden Patah bus-stop, as shown in Figure 5, section b. The balancing index value at this point is 1.06, with the dominance of non-residential land-use in the form of, trade and services with school buildings. The highest balancing index value for Corridor IIIB was located at the Don Bosco stopping point, as shown in Figure 5, section c, with a value of 1.06. The dominance of land-use in this corridor was the use of residential land, as housing and school buildings.

The location with the highest balancing index value is in the Corridor IV area, i.e., at the Nyaliyan Square bus-stop, as shown in Figure 5, section d, with a value of 0.99. The dominance of land use in this corridor, was the use of non-residential land as trade and services, with educational buildings. Furthermore, based on Figure 5, section e, in the

Corridor V area, the highest balancing index value is at the Karang Ayu bus-stop point with 1.00 (very balanced). The dominance in this corridor is a land-use Settlement. The location with the highest balancing index value in Corridor VI, is at the Diponegoro University Nursing bus-stop (educational area), with a value of 1.04. Based on Figure 5, section f, it was shown that, the dominance of non-residential land-use in this area, is in the form of educational buildings. Also, for the highest balancing index, Corridor VII is located at the Petek bus-stop, as shown in Figure 5, section g. The balancing index value at this point is 0.99, with the dominance of non-residential land use, in the form of trade and services.

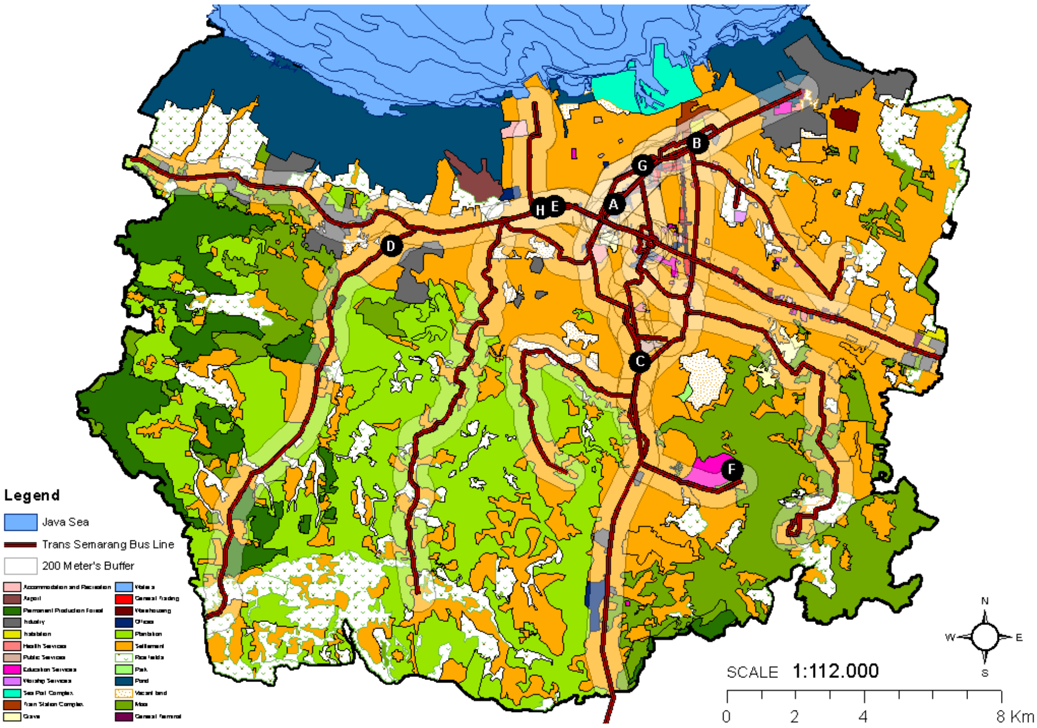


Figure 4. Distribution of land use and location of balancing index sample points in Semarang City.

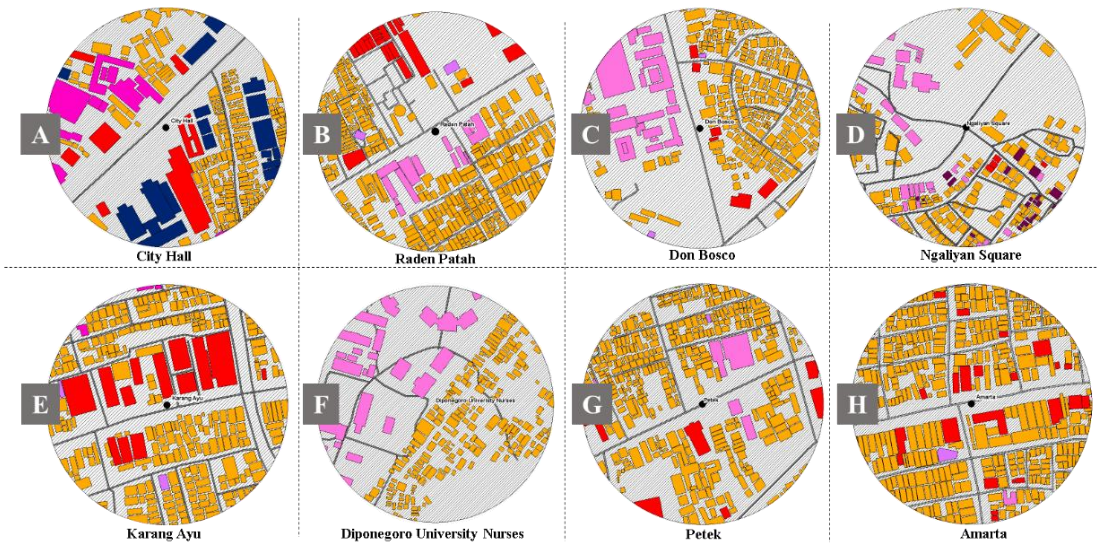


Figure 5. Land use corridor and highest balancing index value (200 meters) ; (A) Corridor II, (B) Corridor IIIA, (C) Corridor IIIB, (D) Corridor IV, (E) Corridor V, (F) Corridor VI, (G) Corridor VII, (H) Corridor I & VIII.

The diversity analysis results for all Bus Trans Semarang corridors, had the same pattern as that of the balance index. The locations with the highest equilibrium index values, were dominated by land-use for trade and services, with education. Also, commercial land-uses (educational with trade and services) increase interest in walking abilities, within the area (Miranda-Morenoa et al., 2011; Townsend & Zacharias, 2010; Chalermpong, 2007). Based on field observations, activities in the area of trade and services also education, are only active in the morning and evening, especially on weekdays (Monday-Friday), pedestrian paths are rarely used during holidays. Furthermore, there needs to be an increase in attractions, in order to bring in and improve activities, therefore, allowing public facilities such as, pedestrian walkway, to function optimally. The areas with mixed land-use characteristics on foot are more attractive, because, the resulting movements are more diverse (Untermann et al., 1984). Therefore, various types of land-use are needed to improve population activities' pattern, in order to optimize the usage of space, and create a sustainable pedestrian system.

Design Analysis

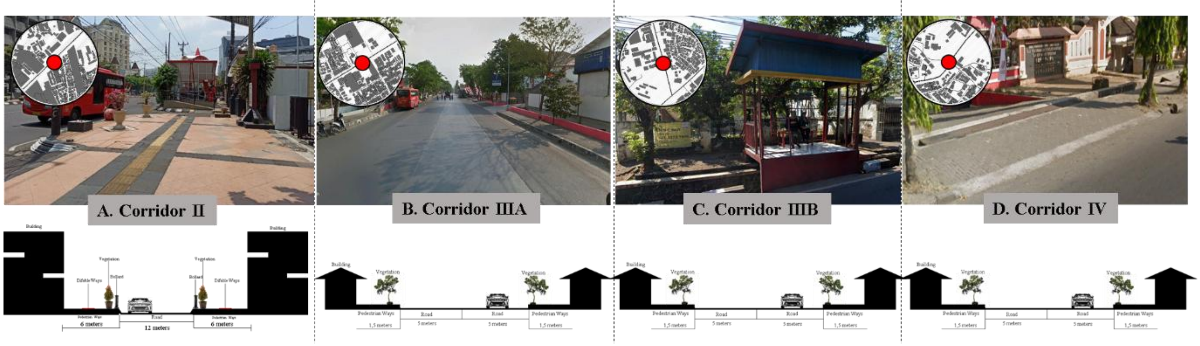
Based on the pedestrian way design analysis, the results showed that Corridors IV, I, and II, are routes with the largest number of inclines, crossings, and irregularities, compared to other zones, as shown in Table 4. Compared with the pedestrian data in Table 1, a linear pattern was observed. Corridors with the highest number of pedestrians, tend to have more complete walker facilities. Another indication was that, the closer to the city centre with a denser population activity level, the better and more complete the pedestrian walkways design becomes. Some locations in areas far from the city centre, traversed by Corridor VI, had pedestrian walkways with a width of 1m-2m, and are only equipped with vegetation, as shown in Table 4 and Figure 6.

Table 4
Complete pedestrian walkways design for the Bus Trans Semarang corridor radius 200 meters

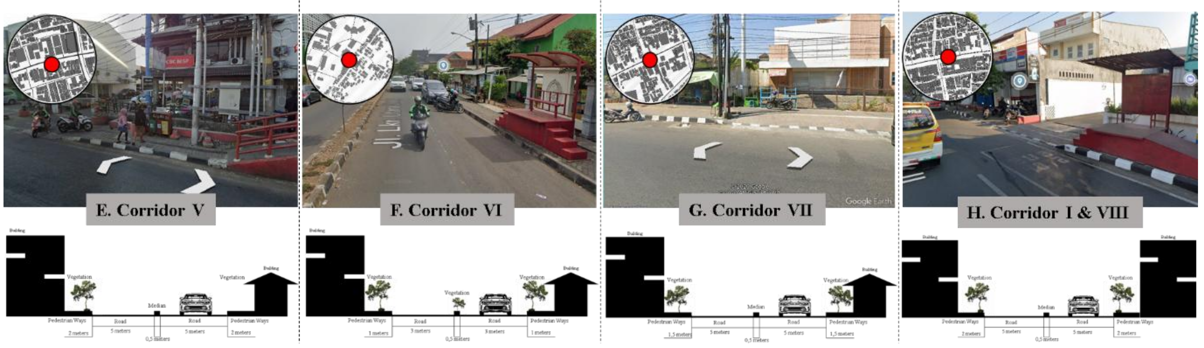
Corridor	Pedestrian walkways Large (m)	Lanes of the road	Number of			Street Furniture
			Inter sections	Ramp	Crossings	
I*	1-5	2 – 6	172	267	42	Shade vegetation, bollards, lights, trash cans, traffic signs, seats, special lanes for the disabled.
II*	1-5	2	165	138	38	Traffic signs (no stopping sign, no parking), street lights, ways with disabilities, and potted vegetation.

Corridor	Pedestrian walkways Large (m)	Lanes of the road	Number of			Street Furniture
			Inter sections	Ramp	Crossings	
IIIA	1-5	1 - 2	95	3	13	Lights, bollards, vegetation, traffic signs, trash cans, fire hydrants.
IIIB	1-1.5	1 - 2	246	0	22	Shade vegetation, and traffic signs.
IV*	1-3	2 - 4	110	396	30	Shade vegetation, bollards, lights, traffic signs, and special lanes for the disabled.
V	0.5-2.5	1 - 2	170	27	31	Shade vegetation, lights, traffic signs, benches, and special lanes for people with disabilities.
VI	1-3	2	132	40	18	Traffic lights and signs.
VII	1-2.5	1 - 2	127	21	12	Shade vegetation, lights, traffic signs, and ways for the disabled.
VIII	1-3	2 - 6	24	184	16	Shade vegetation, special lanes for people with disabilities, and traffic signs.

Note : corridor with the most complete design elements



(a) Sample of pedestrian walkways ; corridor II, corridor IIIA, corridor IIIB, dan corridor IV.



(b) Sample of pedestrian walkways ; corridor V, corridor VI, corridor VII, and corridor VIII.

Figure 6. Pedestrian walkways conditions throughout the Bus Trans Semarang corridor

The sidewalks along the Bus Trans Semarang corridor still needs improvement, because, there is a gap between the current condition and user expectations. The region's undulating topography and climatic conditions, means that the average walking distance in Semarang City, is only 200m-250m. Completeness design components and city environmental conditions of pedestrian walkways, increases people's tendency in walking to a destination (Özbil et al., 2015). Completeness of pedestrian walkways such as, ramps, sidewalks, vegetation, and many more, affects walking activities, when working or not

(Dixon, 1996; Munshi, 2016). However, as a country with a tropical climate and year-round sunshine, the lack of comfort in outdoor activities such as, walking, was an impact. Furthermore, there has to be a need for climate adjustments, by providing vegetation as shade, which is well applied to four-seasoned countries, such as, Montreal, Canada (Miranda-Morenoa, 2011). Therefore, it is necessary to have a pedestrian walkway with complete facilities, and focus on both environmental and climatic conditions, in order to realize a sustainable transportation system.

The Built Environment Model that Affects Pedestrians

Based on the linear regression test results, the partial coefficient T-test method was used, to determine the relationship significance, between two or more variables. In this method, two things were used as benchmarks, i.e., the coefficient T and the significant results. The dependent variable was the number of pedestrian passengers of the Bus Trans Semarang per corridor (Y), with that of the independent being built environment components, namely, the total density (X1), balancing index diversity (X2), the number of walkway design elements (X3), and a radius of 200m. Based on Table 5, which was about the results of linear regression data processing (coefficient T-test), the T-value of density (X1) 0.454 and significance value of 0.669 (>0.05) were obtained. This meant that, the density (X1) does not significantly influence the pedestrian intensity (Y), because of the calculated T-value being less than the T-table (2.353), with that of the significance greater than 0.05.

Furthermore, based on the same table, it was shown that diversity (X2) had a coefficient T-value of 7.028 (> 2.353), and a significance calculated value of 0.001 (<0.05). This results, indicated a significant relationship between the pedestrian intensity (Y) and diversity (X2). The independent variable (diversity), was observed to affect the intensity of pedestrians at the research location, with a direction of positive influence, i.e., the more balanced land-use in an area, the more the desire of a person to take a walk. Based on the same table, it was shown that, design (X3) does not have a significant relationship with the pedestrian intensity (Y). This was because, the variables had a calculated T-value of 1.624, which is smaller than the T-table (2.353), with the calculation of significance greater than the standard of tolerance (> 0.05).

Table 5
The results of data processing linear regression (partial T-test) SPSS

Code	Independent Variable	Unstandardized B	T*	Sig**
Coeficient		2.630		
X1	Density (Floor Area Ratio calculation results)	0.011	0.454	0.669
X2	Diversity (The ratio of residential and non-residential land or Balancing Index)	2.172	7.028	0.001
X3	Design (The completeness of the pedestrian walkways elements)	0.000	1.624	0.165

*Note : The F table value is 2.35: *If T count> T the data table has a close relationship; **Sig <0.05 has a significant relationship meaning.*

Based on the results of the linear regression model in equation 6, it was shown that, the diversity variable had a positive effect on the frequency of pedestrians. The higher the level of balancing index in an area, the more the number of pedestrians increase. However, when the probability of diversity increases by 2.172, the frequency of pedestrians rises by 2.630million in a year.

$$Y = 2.630 + 2.172 \text{ x } 2 \quad [6]$$

The results of this study, are similar to the research conducted in the City of Montreal, Canada. The results suggested that, land diversity influences a person's tendency to walk around the transit centre (Miranda-Morenoa et al., 2011). As with Montreal, land-use as a centre for trade and services with school buildings, dominated the goals of pedestrian movements. Similarly, the research results in Bangkok stated that, the use of commercial land, tends to encourage people to walk around transit centres (Townsend & Zacharias, 2010; Chalermpong, 2007). The environmental conditions along the transit-based transportation routes in Bangkok City, had the closest characteristics to this research. The characteristics of building density and land-use were relatively spread out, from the city centre to the suburbs. Furthermore, another similarity included, the pedestrian walkways not being optimal. The difference between the study results and previous researches, depends on the coverage of the research area, topographical conditions, and urban development policies. Montreal and Beijing city, tends to influence the density component on a person's desire to walk, because of the flat topography, supporting vertical development policies, and the relatively close distance between buildings and transit centres. Also, the pedestrian design elements in these areas are relatively complete, when compared to Semarang and Bangkok City of Thailand. The following is a diagram of the resulting model in Figure 7.

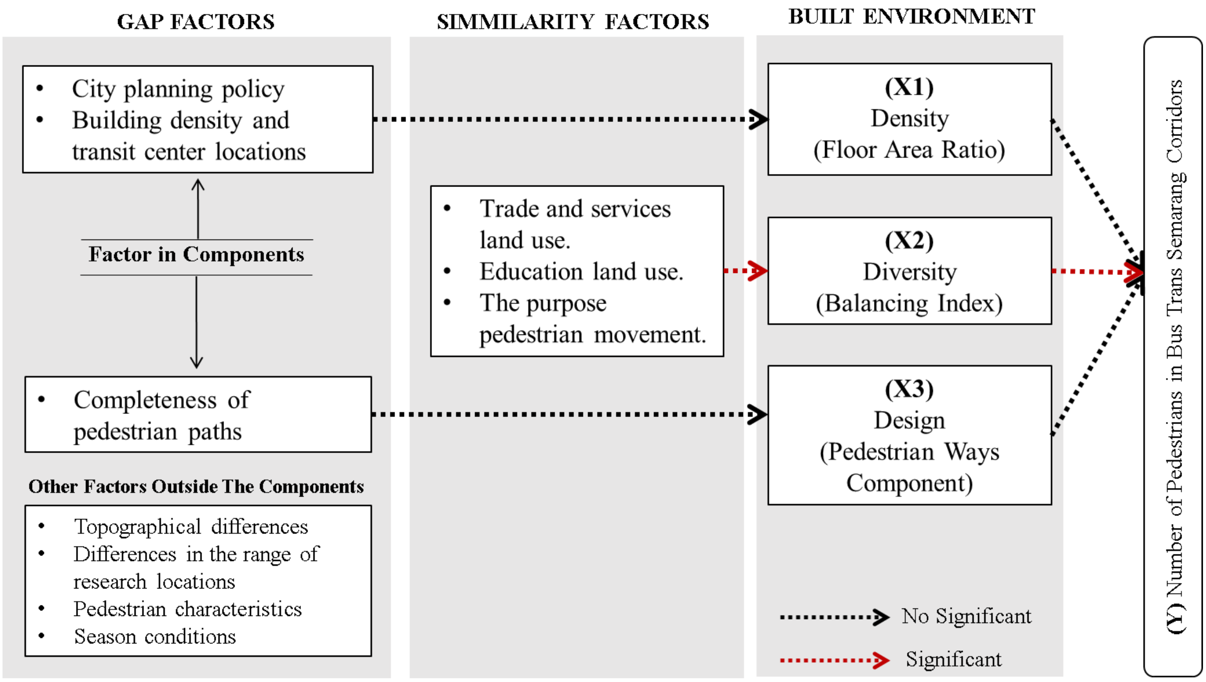


Figure 7. Model diagram for influence analysis of the built environment on pedestrian activity.

CONCLUSION

The analysis results showed that, the diversity component is a feature of the built environment, which significantly influences people's desire to walk along the Bus Trans Semarang. The diversity conditions around pedestrian walkways in Semarang City, showed a high balancing index between residential and non-residential land-uses. Also, the domination of commercial land-use, was in the form of trade, education, and service areas. Furthermore, the high mixed land-use areas tends to affect people's willingness to walk, because the activity patterns are more diverse. The results of the model showed that, there is a positive relationship between the diversity variable, and the frequency of pedestrians, which further indicated that, the higher the level of balancing index, the increase in walkers' frequency.

However, the two other components, such as density and design, did not influence a person's desire to walk. Also, because the optimization of the vertical development is still very minimal, the distance between buildings tend to be far apart. The lack of availability of pedestrian facilities, along the Bus Trans Semarang corridor, especially in the city centre area, were also part of the reasons these two built environment components were not able to influence the desire to walk, in the city of Semarang. Also, it is feared that this issue does affect a person's desire to use transit-based transportation, such as the Bus Trans Semarang. Therefore, it is expected that, follow-up measure is made available, to adjust pedestrians' demands with the built environment, along the Bus Trans Semarang corridor, in order to create a sustainable transportation system.

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DOMINANT INFLUENCE FACTORS ON LAND PRICE IN THE SUBURBS AREA OF SEMARANG

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A B S T R A C T

Today Suburbs area development of Semarang as a result of the development area since a few decades ago tends to influence land prices. It changed by city center distance and connected by better accessibility. Other factors related to the concentration population, socio-economic activities have also influenced it. This research aims to find out what factors on land prices in the Suburbs area of Semarang. The methods used in this study was quantitative analysis include descriptively spatial analysis. The results showed that land prices in each Sub-Urban area were not only influenced by distance to the city center but more local factors of suburban characteristics.

1. INTRODUCTION

The increase in city population led to increasing socio-economic activities. There have influenced the scarcity of land. The dense city development affects the declining environmental quality, such as air quality, water availability, the availability of green space, and so forth. City density gives rise to the development of the suburb (Cao, Shi, & Liu, 2016). This condition causes the dynamics of vacant land to be land built up in the Suburbs area to meet the needs of activities. The development of the suburban regions into new cities that have mutually supporting functions within the town (Wen & Goodman, 2013).

According to the theory, distance decay principle from the center Von Thunen that the value of land will be higher when the distance to the city center is closer (Ha, 2011). Cause the existence close with facilities and infrastructure can affect land prices. The presence of the transport infrastructure will lead to urban growth characterized by changes in land value, land prices, and land utilization along the lines associated with mobility and high levels of accessibility (Ball,

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Cigdem, Taylor, & Wood, 2014; Bruce, 2013). According to Hu, Yang, Li, Zhang, and Xu (2016), the transportation route had a role in the development of the city. However, Von Thunen's theory is not fully applicable, because the land price in the intersection (radial and ring road) will be higher than close the city center. The area has located far from the city center also has to increase the land price because it has a sub-center in the respective area. So the price of land is not only seen proximity to the city center but proximity to other infrastructure that makes it strategic of location.

Indonesia is a developing country in Southeast Asia. The population is increasing every year, but the availability of their land is limited. Where land use influences land prices (Du & Mulley, 2012; Yan et al., 2012). Many big cities in Indonesia are on the island of Java, one of which is the city of Semarang. Semarang City has a strategic location, which is a city that connects the three biggest cities in Indonesia, namely Jakarta, the capital city of the country, Surabaya City, and Yogyakarta City. This strategic location is one of the triggers for the development of Semarang and urbanization. Population development and activities not only occur in the downtown area but also in the suburbs. Rapid growth has happened in all sub-urban areas, both westward towards Jakarta, eastward, Surabaya, and also southward, namely, Jogjakarta. The Semarang city plan makes sub-centers to serve the needs of the community in suburban areas. Besides that, each sub-urban has different functions to support the role and function of Semarang City as the capital of Central Java Province. This phenomenon has pushed the city of Semarang to have a multicenter.

Suburbs development is also influenced by the expansion of the city center, population dynamics, and activities. The dynamics of the most considerable land-use changes occur due to changes in the function of vacant land to the built area to meet community needs. Increased dynamics also happen due to increased provision of facilities and urban infrastructure. The availability of these facilities and infrastructure drives an increase in community activities. In addition to enhancing community activities, the construction of transportation infrastructure will increase the accessibility of Sub-Urban areas. This increase in business and availability has a profound effect on land prices. The Semarang City'S phenomenon is what raises the research question of whether the price of land in the city of Semarang is still strongly influenced by the city center or there has begun to be an even distribution of land prices between the city center and urban sub-center. What are the dominant factors that affect land prices in sub-urban areas in Semarang City?

2. LITERATURE REVIEW

2.1 INTERNAL STRUCTURE

Land value (land value) is always associated with the function, site or location, land productivity, and other factors that provide economic benefits. In practice, the bidding process carried out by individuals and companies who try to acquire land through the market will directly take into account the integral attributes or completeness, namely location, service distance, facilities, supporting activities, environmental quality, social conditions, and transportation. Some theories say the same thing that land prices based on soil fertility (Ricardo-Marx theory), land prices based on metric distances to the center of socio-economic activity (Von Thunen's theory), and the hedonic value theory expressed by Muth, Lancaster, and Rosen, where land prices are determined by intrinsic factors (land area, status), location factors (proximity to centers of activity / socio-economic facilities) and surrounding environmental factors (pollution, noise, ethnicity, landscape, etc.) including accessibility (Orford, 2002).

Hedonistically determined land prices meet many obstacles, such as structural attributes Simans et al., (2006), whose effects on land prices are less tangible and poorly understood. In line with the statement that most of the hedonic models failed to record crucial spatial information in layouts such as network connectivity, network distance, and angular distance, which in turn, has been shown to have a strong influence on land prices (Chiaradia et al., 2012). Land prices are difficult to conceptualize and measure because land prices have a spatial scale; and influenced by many external factors that are interrelated (Orford, 2002). In the study of land prices, using the hedonic approach produces almost the same attribute effect at different locations so that the measurement results are inconsistent. To overcome this problem, researchers have adopted concepts related to urban configurations. In the initial study, accessibility to CBD is usually the primary determinant of site-specific land values. Land location in urban theory has provided a multicentric nuance as well as the location advantage of the urban configuration network/topology (McDonald, 1998). This is also in line with Ellegard & Vilhelmson (2004) that land use that causes changes in land prices is also influenced by other variables, including zoning policies, regional planning, geographical conditions, and topography. This reinforces that in addition to the spatial configuration resulting from zoning policies and local planning, influence land prices.

Like research in the United Kingdom Du and Mulley (2012), states that the Hedonic Model is a traditional multiple regression model that assumes that independent variables are not dependent on each other. The assumption is likely to be damaged if the data are spatially correlated (correlation between variables in space), as is familiar with geographical data. Geographical data tend to follow the law of geography, which is "everything is related to everything, things that are near are more related than things that are far away." Thus, Geographically Weighted Regression (GWR) is used to calculate spatial autocorrelation by adding coordinates to each point that has an influence, which is then explained by several spatially defined factors, including the accessibility of home location transport. Quantification of transport accessibility in this way helps identify increases in value and potential capture of land value associated with spatial with the support of transportation infrastructure.

The spatial configuration in seeing its effect on land prices is to know the distance of other land uses to land as an external variable (Xiao et al., 2015). The distance variable can be used for calculating the measurement of the locational externality effect. To complement the characteristics of research that measures accessibility to benefit points, that is the specific configuration of the study area. Location externalities affect functional relationships with land prices. In the multicentric conceptualization of urban configurations, several variables are needed to capture each of the effects of externalities, and this can cause multicollinearity problems if these variables are correlated throughout space. Besides, it can be used to see the true nature of urban configurations with land markets and their impact on processes spatially.

According to Dursun and Saglamer (2003), spatial relations are relationships that occur

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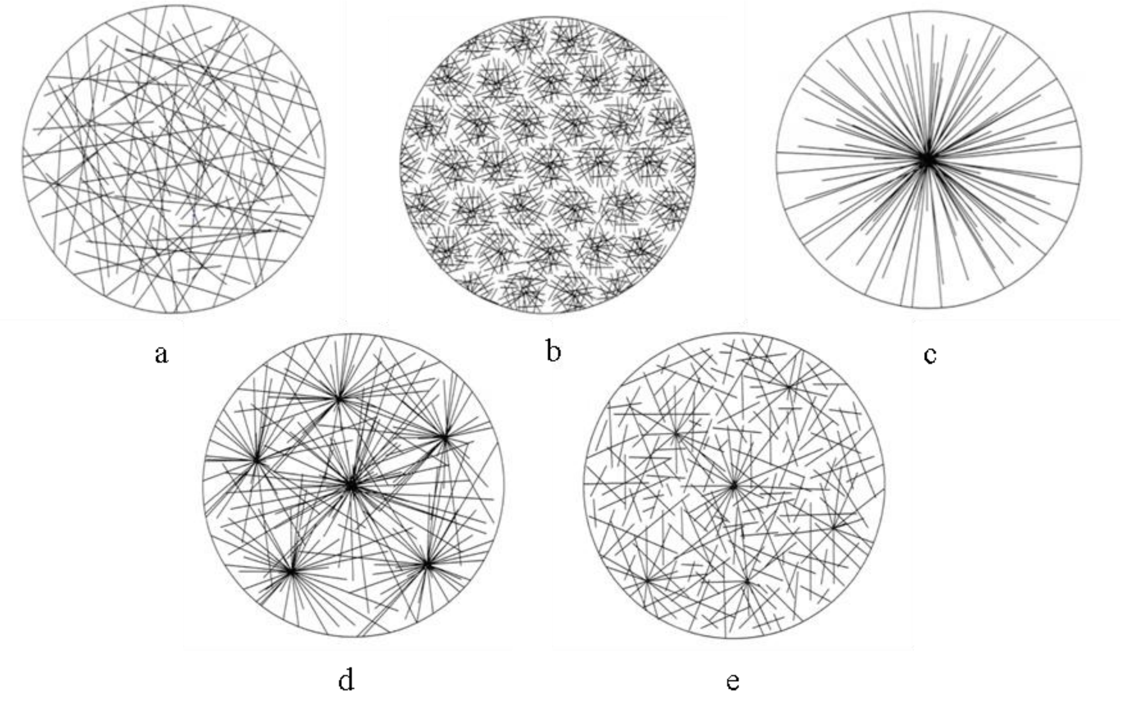
between the two areas. A configuration exists when the relationship between the two spaces changes according to how it is connected. Therefore, the description of the configuration relates to how the space system is interrelated to form a pattern, not the more localized nature of a particular space. Spatial configuration affects the pattern of movement in space, and the movement of shapes that influence the use of space. Through the impact of this movement, spatial configuration naturally stands to determine patterns that occur in socio-economic conditions of the population in and around an area. Based on **Figure 1**, there are spatial patterns introduced as five models of urban spatial structure in the movement of work from the residence to the workplace (Angel & Blei, 2015), among others:



Source: Angel & Blei, 2015

Figure 1 Spatial Pattern; a) Maximum Disorder Model, b) The Mosaic of Live-Work Communities, c) The Monocentric City Model, d) The Polycentric City Model, e) The Constrained Dispersal Model

a) The maximum Disorder Model, where the place of residence and destination of work is distributed randomly throughout the area, and workers returning from random places to work are also random.
b) The Mosaic of Live-Work Communities Model, i.e., the pull between settlements and workplaces, is very strong. Commuter costs are very high because of limited transportation technology or because of a strong preference for working at home or walking or cycling to work, so everyone who works lives near the workplace.
c) The Monocentric City Model, where all workplaces gather at one location and at locations that are close to one another and maybe near tourist areas, ports, mines, places of worship, or transportation centers. All work is concentrated in the Central Business District (CBD).

Workers who live on the out of the city circle far from CBD will travel back and forth on the radial route to their work in the CBD.

d) The Polycentric City Model, i.e., the workplace is still united by a strong pull and is concentrated in several centers spread throughout urban areas, not only in the CBD (Lee, 2006)

e) The Constrained Dispersal Model that is in this model the weak centripetal power that still exists in most workplaces such as the CBD in the Monocentric City Model and the inability to create employment sub-centers in the Polycentric City Model to attract workplaces that leave the CBD. The majority of workplaces are spread outside the sub-center or from the CBD.

Many studies have analyzed the polycentric city as one way to improve the efficiency of spatial configuration. One of them is Beijing City, which has tried to decentralize spatial configuration by implementing a series of policies (Huang et al., 2017). Beijing focuses on creating polycentric space structures by promoting subcenters in the suburbs, including industrial development zones, satellite cities, and new cities. By implementing this strategy, the Beijing government hopes to reduce employment in the city center and make suburb areas more attractive to companies and residents. Polycentricity is also considered a normative tool to achieve important goals in terms of environmental sustainability and social cohesion (Davoudi, 2003). However, some research shows that polycentric cities can result in a loss of economic efficiency due to large public investments in decentralized development (Ding & Bethka, 2005). Generically, multicenter development can fail to reduce worker travel even though there is a considerable commuter distance (Tamin, 2000). Thus, the polycentric impact on urban development is still a very simplified topic (Veneri, 2013). Knowing the factors that affect land prices in Semarang City by linking various interests that affect land prices will be able to help determine whether the city center is still increasing land prices. Variables to be tested are analyzed by multiple linear regression.

3. METHOD

3.1 STUDY AREA

This research is conducted in the Suburbs area of Semarang. Based on Figure 2 the Suburbs area of Semarang is divided into three areas, namely the Suburbs East of Semarang, Suburbs South of Semarang, and West of Semarang. The East of Semarang consists of the Genuk sub-district and the Pedurungan sub-district. The South of Semarang consists of the Gunungpati sub-district and the Tembalang sub-district. The West of Semarang Barat consists of the Mijen sub-district, Ngaliyan sub-district, and Tugu sub-district. Each of these Sub-Urban areas at this time has also been being passed route of public bus transportation is called BRT Trans Semarang.

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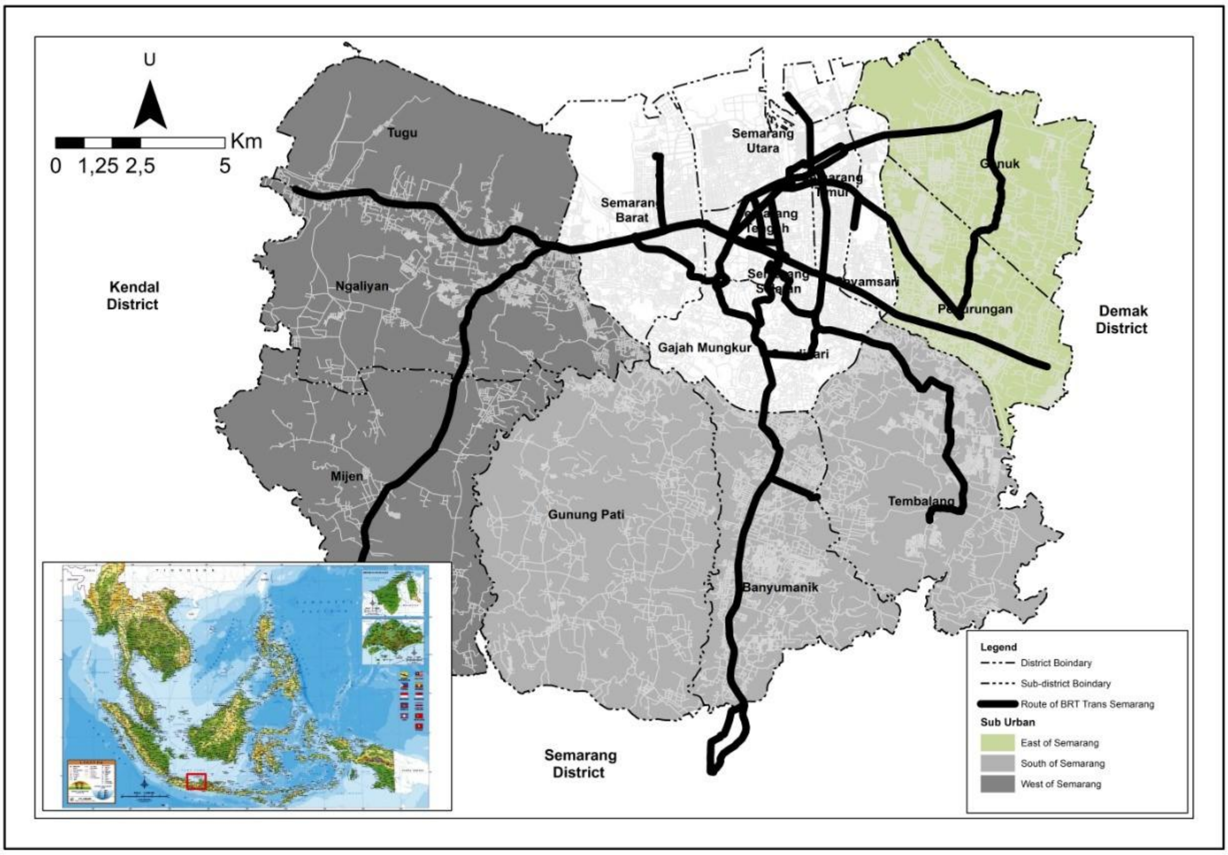

Source: Author's Analysis, 2019; from Shapefile Bappeda Semarang City, 2011

Figure 2 Sub Urban Area Map

3.2 DATA COLLECTION

The data of this study are data about factors that affect land prices in the Semarang City area, including land prices, the distance between city center locations, distance between locations and Trans Semarang BRT stops, the distance between locations and health facilities, the distance between locations and education facilities, the distance between locations and recreational facilities, and the distance between locations and trade facilities. Data was collected through observation in 2019. Distance data from these facilities was used as an independent variable in the process of multiple linear regression analysis to determine what factors affect land prices. Besides, demographic data is also needed, including the total population, type of work, and the number of private vehicle ownership. This data was obtained by examining documents such as BPS documents. All of these data would provide a general description related to the socio-economy in the Suburbs of Semarang.

3.3 METHODS

3.3.1 QUANTITATIVE ANALYSIS

Quantitative analysis of the study used multiple linear regression analyses using SPSS. This analysis was found the effect of infrastructure on land prices. These influences can be seen based on infrastructure distances that are variables in the analysis. While the dependent variable used the land prices in the suburbs area sold or rented. The result of this analysis was to define an independent variable that influences the land price and relationship value between the independent variable and the dependent variable. Through several linear regression analysis methods, it would be answered what factors can affect land price in the city of Suburbs Semarang. The formula for use as a study was as follows:

$$Y = a + BX1, CX2, DX3 + EX4 + FX5 + GX6$$

Description:
A: Constants
X1: Distance of City Center
X2: Distance of Shelter BRT Trans Semarang
X3: Distance to Health facilities
X4: Distance of Education facilities
X5: Distance of Recreational facilities
X6: Distance to Trading facilities
Y: Land Price (IDR/m^2)
(B, C, D, E, F, G): Coefficient of the independent variable

3.3.2 SPATIAL DESCRIPTIVE ANALYSIS

Spatial descriptive analysis of the study consisted of identification of the characteristic distribution of suburban areas aimed at determining the characteristics of each Suburbs area. The region's characteristics can be seen based on demographic conditions and socioeconomic conditions. The data associated with the average land price, the number of people with livelihoods as labor for industry and construction, and the amount of car ownership. The data used to analyze the effects of area characteristics on land prices. Also, descriptive analysis is used to present data in the form of graphs, diagrams, and tables that are then analyzed and explained according to the data obtained.

4. RESULT AND DISCUSSION

The study results show that the price of land in suburban areas is not only influenced by the distance of the location to the center of the city, but other variables influence it. Based on **Figure 1**, there are even suburban areas where land prices are not affected by the city center. The following table shows the mileage effect on the specified variables in each of Semarang's Suburbs areas:

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Tabel I Variables that Influence Land Prices in Semarang City

Independent Variable (km)	East of Semarang	South of Semarang	West of Semarang
The distance of City Center	A	NA	A
The distance of Shelter BRT	NA	NA	NA
The distance of Health Facility	NA	NA	A
The distance of Education Facility	A	A	NA
The distance of Recreation Facility	NA	NA	NA
The distance of Trading Facility	NA	NA	NA

Source: Author's Analysis, 2019

Explanation :

A = Available = Affects land prices

NA = Not Available = No effect on land prices

The result from regression analysis using SPSS can be shown below

East of Semarang

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	16,261	1,270		12,803	,000
	City Center	-,658	,128	-,559	-5,128	,000
2	(Constant)	18,713	1,658		11,286	,000
	City Center	-,780	,136	-,663	-5,735	,000
	Education Facility	-1,814	,823	-,255	-2,205	,032

a. Dependent Variable: Land Prices

South of Semarang

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	15,504	1,634		9,487	,000
	Education Facility	-5,050	1,986	-,324	-2,543	,014

a. Dependent Variable: Land Prices

West of Semarang

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1,399	3,893		,359	,721
	City Center	6,112	2,146	,429	2,848	,007
2	(Constant)	8,120	4,575		1,775	,085
	City Center	7,248	2,066	,508	3,509	,001
	Healthy Facility	-9,580	3,931	-,353	-2,437	,020

a. Dependent Variable: Harga Lahan

So we get the regression equation as follows:

Table II Regression Equations

Suburbs	Regression Equations
East of Semarang	Y = 18.713 - 780 X1 – 1.814 X4
South of Semarang	Y = 15.504 – 5.050 X4
West of Semarang	Y = 8.120 +7.248 X1 - 9.580 X3

Source: Author's Analysis, 2019

Based on the multiple linear regression model in **Table II**, land prices in each suburb area are influenced by different independent variables. The price of land in the East Semarang Suburbs area was influenced by distance to the city center and educational facilities. While the price of land in the Suburbs area of West Semarang was influenced by the distance of the city center and health facilities, these two suburb areas are a residential function and have activities that are still dependent on the city center, so that the city center still has a large influence on the development of this suburban area including the land price. The coefficient on the distance between the location of the location with the city center in the two suburb areas was smaller than the coefficient of distance to the education or health facilities, and this shows that land prices are influenced by spatial conditions.

Land prices in the suburbs of South Semarang are influenced by distance to educational facilities. The distance to the city center does not have a significant effect because, in this region, there are regions that have a national-scale educational function that can attract large activities in the region. So that educational facilities in the region have a significant influence on the development of areas including land use and land prices. The price of land, which was no longer affected by the distance from the city center, shows that the city of Semarang has a polycentric spatial pattern. Polycentric patterns are also seen in land prices in all suburb areas, which are very volatile to the sub-urban center, as in **Figure 3**. Land prices at locations away from the city center do not necessarily decrease, but tend to fluctuate at some points. The results of this study are not in line with Von Thunen's theory that the closer the land point is to the city center, the higher the land price. In line with what was stated by Guangzhong Cao (2016) that the formation of urban areas was exogenous and based on CBD when viewed in the gradient of land rent allowing the descending pattern of the CBD but there can also be a maximum upward pattern in sub-center centers even further outside the CBD or downtown.

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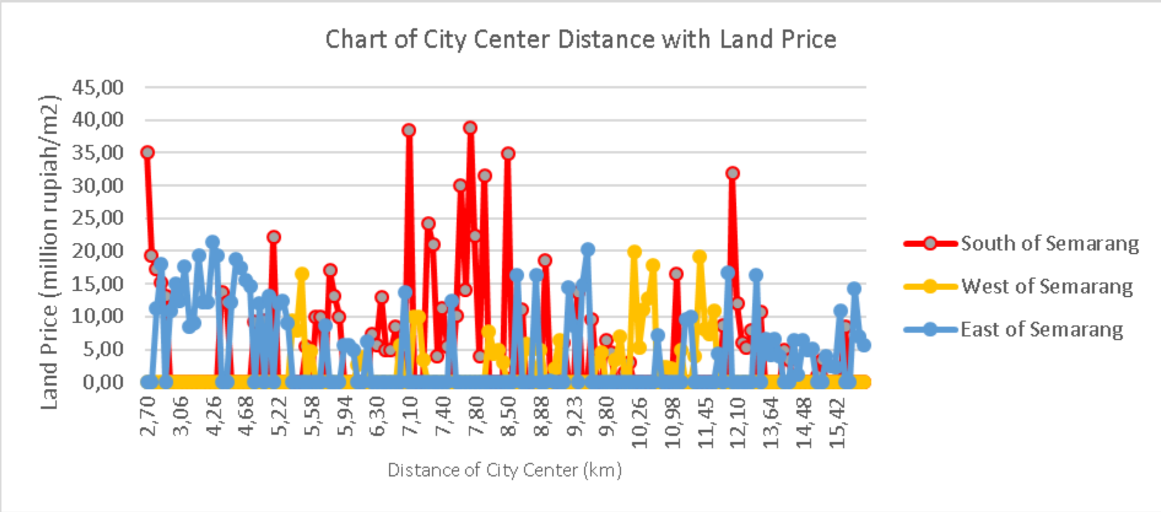
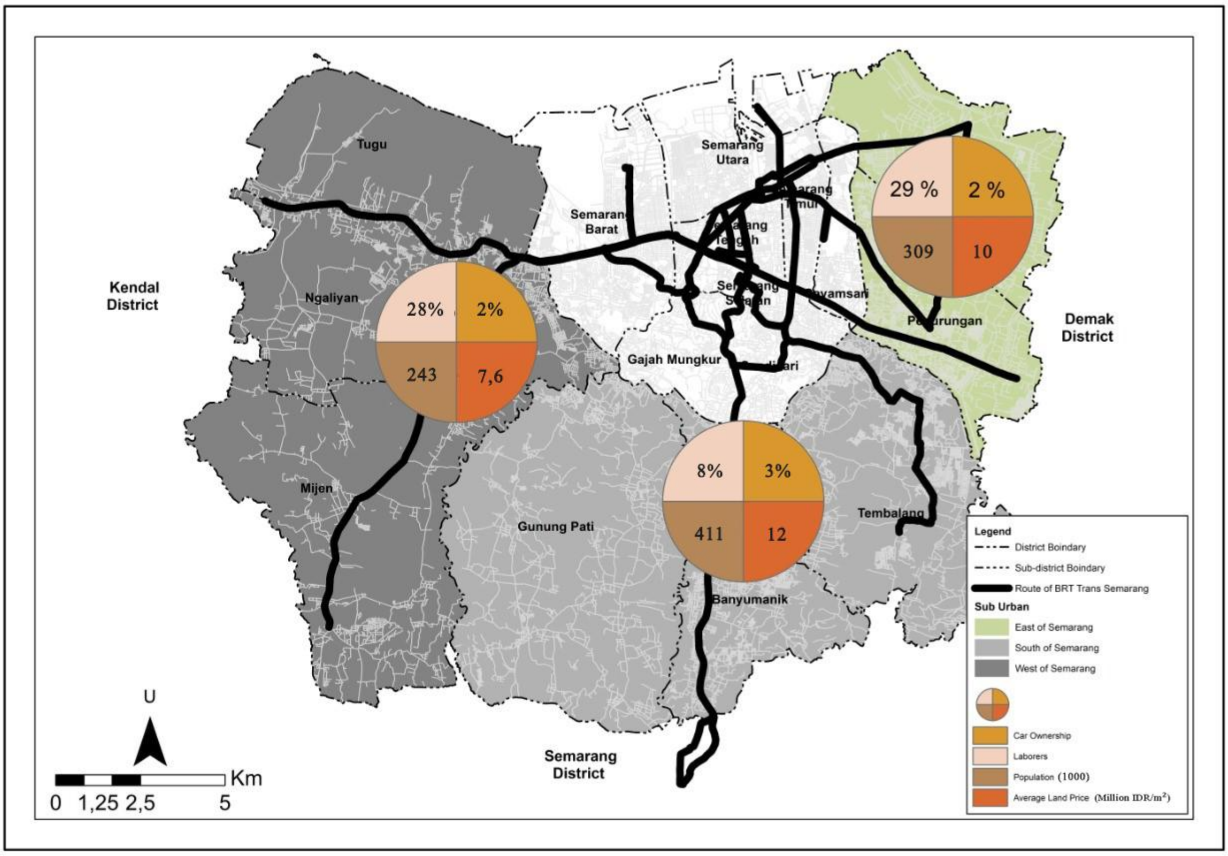


Source: Author's Analysis, 2019

Figure 3 Graphic Relationship between Land Prices and City Center Distance

Suburb characteristics also support the growth and development of the area, including demographic data. Including changes in land and land prices in sub-urban areas in Semarang City are also influenced by these characteristics. In this study, the data analyzed were population data, employment data, and private vehicle ownership data.



Source: Author's Analysis, 2019; Statistical Data from Semarang Central Statistics Agency, 2019; Shapefile from Bappeda Semarang City, 2011.

Figure 4 Map of Characteristics of Sub-Urban Areas

Based on **Figure 4**, the percentage of total car ownership in the East Semarang sub-urban area was 2%, in the South Semarang sub-urban area was 3%, and in the West Semarang sub-urban area was 2 %. This shows that the sub-urban area of South Semarang has the highest percentage compared to other sub-city areas. The percentage of population-based livelihoods as industrial and construction laborers in the East Semarang sub-urban area was 29%, the South Semarang sub-urban area was 8%, and the West Semarang sub-urban area was 28%. The result shows that the sub-urban area of South Semarang has the lowest percentage compared to other suburban areas. These two data can show that economic conditions in the Suburbs area of South Semarang have higher economic conditions compared to the other two sub-urban areas. This economic level can represent a high quality of life, so people want to buy land at a higher price by choosing land in a better environment. Land prices in the South Semarang Suburbs area also have the highest average land prices compared to other suburb areas. This shows the socio-economic characteristics affect the land selection and, subsequently, the overall price of land area. So it could be that the price of land in a suburban area can be the same or even higher than the price of land in the city center.

5. CONCLUSION

Based on the results of the analysis, it can be noted that land prices are not only influenced by the distance to the city center but more the location of the spatial land and local factors from the suburbs. Some characteristics can be activities that have high attractiveness. This characteristic is in the form of the socioeconomic population in the area concerned. Also, some facilities have great appeal so that they can affect the price of land at a location, so it does not only depend on the distance from the city center. Besides, the sub-urban center can also influence the price of land, as evidenced by the price of land that tends to rise close to sub-urban even though it is far from the city center.

This was in line with research Amarin, Taha, and Emily (2019) attraction of a region that can come from various characteristics of urban configurations or urban spatial arrangements Xiao, Orford, and Webster (2015) that have specific and different attraction forces in each suburbs area. Indonesia, the power of characteristics area, can vary due to the uniqueness of urbanization and complex social-economic activities in developing countries. So a strong influence on the city center was more easily applied to cities that have concentric structures. However, the results showed that in Semarang, the city structure had shifted from monocentric to polycentric so that the city center did not have a significant influence on changes in land prices and land use in all areas of the city. As with changes in the spatial structure of major Chinese cities Daquan, Zhen, Xingshuo, and Pengjun (2017), from monocentric to polycentric because of increased activity and development of suburban infrastructure.

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6. AVAILABILITY OF DATA AND MATERIAL

Statistical data was openly available through the Semarang City Statistics Agency website and shapefile data has obtained permission from the Semarang City Bappeda. Other data can be made available by contacting the corresponding authors.

7. ACKNOWLEDGMENT

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3. Revisi 2

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The Built Environment and Its Impact on Transit Based Transportation User Walking Activities in Semarang, Indonesia.

The Built Environment and Its Impact on Transit Based Transportation Users Walking Activity in Semarang, Indonesia.

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List of Table/Figure:

ABSTRACT

Currently, an increase in population with a rising need for mobility, has become a challenge in urban development. The pedestrian walkways that are integrated with transit centers based-transportation has been developed, to minimize problems due to the high level of mobility of the urban population. Some experts say that environmental conditions are one of the main factors that can affect the frequency of pedestrians. This study aims to explore the affect of the built environment (such as density, diversity, and design), on the pedestrian frequency of the Bus Trans Semarang passengers. The research of data collection was carried out on 9 corridors, consisting of 447 bus stops, directly connected to the pedestrian walkways, as one of feeder for transit-based transportation facilities. The analysis method used for each variable was the formulation technique and data simulation, using applications, such as ArcGIS, with the linear regression partial t-test model using SPSS, as well as determining the effect of pedestrian frequency (dependent variable), and the built environment elements (independent variable). The results showed a positive significance between the diversity variable and the frequency of pedestrians along the Bus Trans Semarang corridors. Furthermore, the land that varies with the dominance of commercial and educational area, has the highest attraction features that affects a person's frequency to walk.

KEYWORDS
Built Environment, Transit Based Transportation, Pedestrian Walkways.

INTRODUCTION

The development of a transit-based transportation system is carried out intensively, as an alternative method to overcoming population growth and private transportation, in various countries. The Asian region is generally known for its unhealthy transportation system, which causes various problems, such as congestion, air pollution, and sprawl issues (Makarova et al., 2017). In order to overcome this, the World Health Organization (WHO), encouraged countries to implement sustainable transportation systems, that focuses on safe, efficient, accessible, affordable, inclusive, green, and healthy transportational mobility.

A Transit-Oriented Development (TOD) is a form of sustainable transportation, that emphasizes on integrating urban spatial design, to unite people, activities, buildings, and public spaces, through connectivity, which is accessible by walking (Institute for Transportation & Development Policy, 2017). Increasing walking intensity (walkability), is considered as part of the effective solutions in overcoming unhealthy transportation, because it minimizes congestion, increases environmental sustainability, encourages physical activity, improves public health, and enhances the appropriateness of urban settlements (Blanco & Alberti, 2009). The pedestrian walkways, commonly referred to as a sidewalk in a transit-based transportation system, is a facility feeder, connecting a transit centre with other activity functions (Hu et al., 2013). However, the lack of optimal pedestrian walkways is a challenge for establishing a sustainable transportation system in several countries.

Various studies suggested that the optimization of pedestrian walkways, such as the completeness of design components, an attractive, safe, and comfortable city shape can increase residents' tendency in walking to a destination (Özbil et al., 2015). Also, the built environment adjustment with land-use planning and urban design are crucial in increasing pedestrian activity in cities (Timmermans, 2009). However, research on the relationship between the conditions of the built environment, and walking tendency in the transit-based transportation system, is still rare. Furthermore, various parties have been inclined to focus at increasing the capacity of the transportation system, without observing how the developments that occur affect the environment. Therefore, the development of a new transportation system is observed to be linear with the uneven distribution of building density and land-use management, resulting in several pedestrian walkways not functioning properly.

The built environment in the transit-based transportation system, commonly found in Europa region countries. The initial milestone in the research on the built environment, was first carried out by Cervero, in the European region, as an agenda to welcome the new urbanism concept (Cervero & Kockelman, 1997). That study stated the built environment means physical features of the urban landscape (i.e. alterations to the natural landscape). In assessing the built environment from the same source, three main components were the author formulated, namely density, diversity, and design.

The density is defined as the component produced by observing population frequency per household and building quality per area (Cervero & Kockelman, 1997; Monteiro & Campos, 2012; Zhang et al., 2016). Furthermore, the research on the built environment and pedestrian activity in previous studies, observed that the areas with high level of density tend to have a high intensity of walking (Oktaviani et al., 2020). A study conducted by Duduta (2013), developed indicators for assessing density components, in the form of constructing measurements, which are well related to building height or the Floor Area Ratio (FAR) analysis method. The study, takes a minimum distance of 200m from the stop point was recorded, and divided into three categories of level assessment, i.e., low (1-2 floors), medium (3-8 floors), and high (>8 floors) densities.

The diversity component is represented as a land-use balancing index by comparing the ratio of residential and non-residential (commercial) land use. As the level of balancing land-use in an area rises, the activities of pedestrians relatively increased (Sung & Choi, 2013). Furthermore, simplifying the research of Cervero and Kockelman (1997), the diversity component emphasizes on the calculation model of residential and non-residential land area ratios, which in this case, is measured by the balancing index formula (Sung & Choi, 2013). Broadly, the results of the diversity variable analysis can show the patterns of land use and its changes due to population mobility. Several studies such as that conducted by Cervero, found that the effects of diversity have just as long been ignored.

The design component is part of the features referring to the assessment of pedestrian walkways, and its integration with the road network system (Dixon, 1996; Munshi, 2016). Same as diversity, the effects of design also have just as long been ignored in built environment analysis. However, the design component's measurement is more complex than that of the other two (density & diversity), with a system of assessing the elements of pedestrian walkway completeness, adjusted to environmental conditions (Zhang et al., 2016). This study summarized the design indicators needed to identify the appropriate pedestrian walkways at the research location. The includes the lane width, route count, road intersection number, the presence of ramps, bridges, and zebra crossings, as well as the completeness of street furniture.

The country context has an essential role in ascertaining the built environment assessment of pedestrian activities. The biggest question emerging from previous research, is based on whether the context of the built environment in the European region remains the same as that in the Asian zone. Furthermore, a research in downtown Montreal, Canada showed that the components of the built environment, density (population, number of jobs, schools, and bus stops); diversity (commercial land use); and design (percentage of main arteries, average length of roads), affects pedestrian activity (Miranda-Morenoa et al., 2011). This city's position in Canada State, is a provincial capital which is not included in the national central area, and is observed to be a part of the cities located in developed countries. In this location, the problem encountered is the provision of pedestrian walkways, such as the lack of pedestrians' security. On the other side, this location already had a complete pedestrian walkways element, with skyscrapers all around it. As a four-season country, the provision of vegetation along the pedestrian walkways in the city, is designed to suit seasonal conditions. Because the designs that adapt to climate change and periods, are being intensified, in a bid to create sustainable urban life.

The discussion of the built environment, on pedestrian walkways in developing countries, for example the transit area in Bangkok, Thailand, obtained results in the form of an interplay, between people's tendency to walk, and the diversity of land-use around the transit area (Townsend & Zacharias, 2010). The walkways condition in Bangkok, Thailand, is confronted with air pollution and lack of sidewalks (Townsend & Zacharias, 2010; Chalermpong, 2007). From the study, the development of commercial, retail, and residential land is relatively high around the transit centre, which shows that, the influence of diversity is high enough on pedestrian movement patterns.

The research conducted in other Asian regions, such as Beijing, China, obtained different results. The findings on the built environment, at the environmental-scale transit centres in Beijing, showed that, the density component plays a substantial role in influencing pedestrian activities (Zhao et al., 2018). In that study, the pedestrian walkway components in this country, is complete compared to the provision in Bangkok. Also, the influence of the vertical building construction policy in the central area of Beijing City, is the basis for the formation of a compact area, with relatively close distances between buildings. Based on that statement, the density of the built environment in this area influences a person's inclination to walk. Therefore, the geographic characteristics with scope of the research conducted in Bangkok and Beijing, are relatively the same, because it is often carried out in location with relatively flat homogeneous topography, with city scale research coverage.

Semarang is one of the major cities in Indonesia, which is located in Central Java Province. The city intensively plans to develop a Transit Oriented Development (TOD) system, to accommodate the mobility needs of the community, and create a sustainable transportation channel. Furthermore, a part of the requirements needed for the development of the TOD system in Semarang City, is the Bus Trans Semarang. Observation of the relationship between the built environment and pedestrian activities in the central transit area, along the Bus Trans Semarang corridor, seems interesting, because, it covers the city centre area and its surroundings has a diverse topography. The problem of pedestrian walkways provision in Semarang City, is the same as that of Bangkok (i.e., pollution issues, and lack of sidewalks). Based on further data, it was observed that, about 88% of Bus Trans Semarang passengers walked to or from the bus stops (Purwanto & Manullang, 2018). This result is certainly in contrast to the lack of pedestrian walkways provision in the city of Semarang, which then causes a gap between availability and demand.

Policies regarding land-use, regulated by City Territory Section (CTS), observed that, the use of land in Semarang City is very diverse. The absence of a firm policy on building construction efforts, has resulted in a high sprawl level in this area. Therefore, this study aims to ascertain the best built environment model, that affects a person's tendency to walk along the Bus Trans Semarang corridor, from the city centre to the suburbs. As well as being a complement to previous research which only focused on density conditions in the built environment analysis. This is further accompanied with a research question, in the form of, Do the built environment components affect the pedestrian activity of transit-based transportation users in Semarang City?.

STUDY METHODOLOGY

Semarang Study Area

Semarang City is one of the metropolitan cities in Indonesia, located in Central Java Province, with a population of 1.79million. According to the data obtained from the Semarang City Statistics Centre in 2019, the population of the area keeps increasing by 50% yearly, accompanied by the provision of a public transportation system, which is not yet optimal. This location is one of the pilot project for Bus Rapid Transit (BRT) development in Indonesia, with the provision of Bus Trans Semarang in 2009, to help improve the quality of transportation system (SuaraMerdeka, 2015).

The location in this study covers all Bus Trans Semarang routes, consisting of, Corridors I, II, IIIA, IIIB, IV, V, VI, VII, and VIII, as shown in Figure 1. According to Kim et al. (2018), there are two methods to measure the built environment, based on the area's scope, i.e., the street level of 50m, and the neighborhood position at a maximum radius of 400m, from the observation point. The data showed that the maximum distance for walking in Semarang City, is only 200m-250m between destination locations (Purwanto & Manullang, 2018). Therefore, sampling of the observation area, by using the neighbourhood level method, with a radius of 200m from the right and left of the road was carried out.

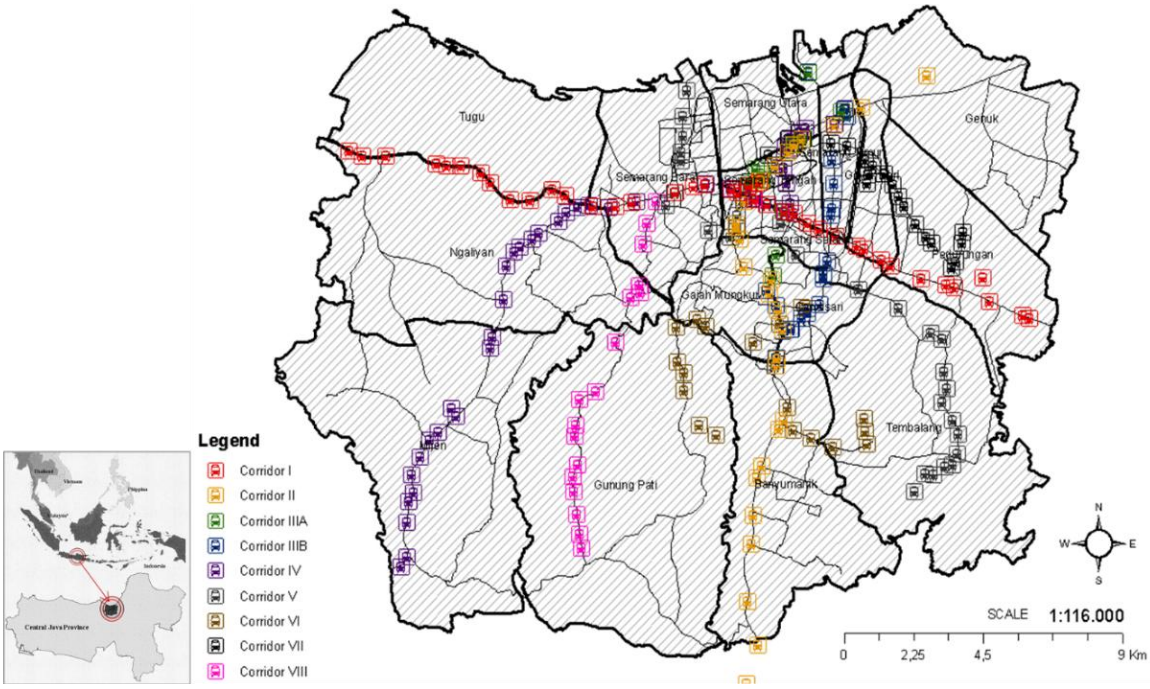


Figure 1. Bus Trans Semarang stops in the study area

In this study, the entire Bus Trans Semarang corridor has 596 bus-stops, scattered from the city centre to the suburbs, while also connecting various important land-uses, such as, terminals, government areas, education fields, and many more, as shown in Table 1. Data from the Semarang City Transportation Office in 2018, showed a significant increase in the number of Bus Trans Semarang passengers, from 2010-2018. The total number of passengers between 2010 and 2018, were 369,326 and 10,210,296, respectively. Furthermore, the largest contributor for pedestrians in this study, was Corridor I, which had massive bus-stops and fleets, compared to the other eight. Based on the data collected from the field observations, pedestrian activities along the Bus Trans Semarang corridor were dominated by school, work, and recreational activities. City centre areas such as, Corridors I, II, and IV, had more massive pedestrian activities, than other zones.

Table 1
Bus Trans Semarang corridor profile

Corridor	Rute	Number of			Corridor Length (Km)	Operating Years
		Pedestrian (People)	Bus (Unit)	Stops (Unit)		
I*	Mangkang Terminal→Penggaron Terminal.	2,713,852	25	81	60.0	2009
II	Terboyo Terminal→Sisemut Terminal.	838,081	34	74	26.5	2012
IIIA	Tanjung Emas Port→Kagok→Tanjung Emas Port.	166,934	16	45	10.5	2014
IIIB	Tanjung Emas Port→Elizabeth Hospital→Tanjung Emas Port.	111,289		40	10.0	2014
IV	Cangkiran Terminal →Semarang Tawang Station.	520,436	22	87	22.3	2013
V	Meteseh Residential Area→Airport→Marina Beach.	366,319	16	75	25.9	2017
VI	Diponegoro University→Semarang State University.	257,831	16	63	13.4	2017
VII	Terboyo Terminal→Semarang City Hall.	87,886	13	63	6.9	2018
VIII	Cangkiran Terminal→Simpang Lima (City Center).	56,799	20	68	22.4	2019

*Note : *corridors with the most pedestrians*

Quantitative Analysis

The method used in this study, was a quantitative research technique, which focuses on analyzing the built environment, in the form of, density, diversity, and design. The retrieval of data for analysis was carried out, using naturalistic observation methods, which observed the research object's condition in a more realistic means, directly to the field. Furthermore, density analysis assessed population frequency, by comparing the total populace, using the interpolation method (ArcGIS 10.3). This analysis produced a spatial picture of population density in each corridor. Also, the density component analysis used numerical calculation method, Floor Area Ratio (FAR), by comparing the number of buildings per floor area. The calculations by Duduta (2013), was divided into three categories, i.e., low (equ 1), medium (equ 2), and high (equ 3) densities, as follows,

$$\text{Low density} = \frac{\text{number of buildings } 1-2 \text{ floors}}{\text{the total number of buildings within a 200 meter radius of the stop point}} \quad [1]$$

$$\text{Medium density} = \frac{\text{number of buildings } 3-8 \text{ floors}}{\text{the total number of buildings within a 200 meter radius of the stop point}} \quad [2]$$

$$\text{High density} = \frac{\text{number of buildings} > 8 \text{ floors}}{\text{the total number of buildings within a 200 meter radius of the stop point}} \quad [3]$$

Diversity components were analyzed, using the land-use ratio analysis, while comparing the land (residential, commercial, office space, public services, and recreational), to the total space area, around the Bus Trans Semarang bus-stop, in each corridor. According to Sung and Choi (2013), this diversity of land-uses were explained, by using the balancing index (RNR) formula (equ 4), to compare residential and non-residential land-use.

$$RNRi = 1 - \left[\frac{Res - Nonres}{Res + Nonres}\right] \rightarrow \text{The closer to 1, the more balance} \quad [4]$$

Analyzing the design component was carried out, by looking at the road structure and the completeness features of pedestrian walkways, based on movement needs. In this case, the assessment indicators were the elements of completeness, which includes, crossings, ramps, intersections, lane width, number of routes, and sidewalk furnitures. The analysis of this component was presented, to visualize the existing conditions, and compare them with the required pedestrian feature demand data, in Semarang. The overall results of the density, diversity, and design analysis, were processed, using the significance of linear regression (partial T-test) and the SPSS Statistics 24 application, to determine the effect of the built environment on walking activities, in each corridor. The model formula, used in determining the influence between variables, is shown in Equation 5 below.

$$Y = a + b(X) \quad [5]$$

Where;

Y = frequency of pedestrians (person)

a = constant

b = coefficient

X = built environment variables

Linear regression had been widely used in previous researches, to produce a relationship model, between the built environment variables and pedestrian movement patterns in an area. The requirements of linear regression analysis (partial T-test) is that, when the results of the coeficients (t) are greater than the t-table (2.35), with the significance value of the regression data less than 0.05 (<0.05), then it is confirmed that both variables (dependent & independent), influences each other. The built environment variable consisting of, density (X1), diversity (X2), and design (X3) as independent variables, correlates with the pedestrian intensity in each corridor (Y), as shown in Figure 2.

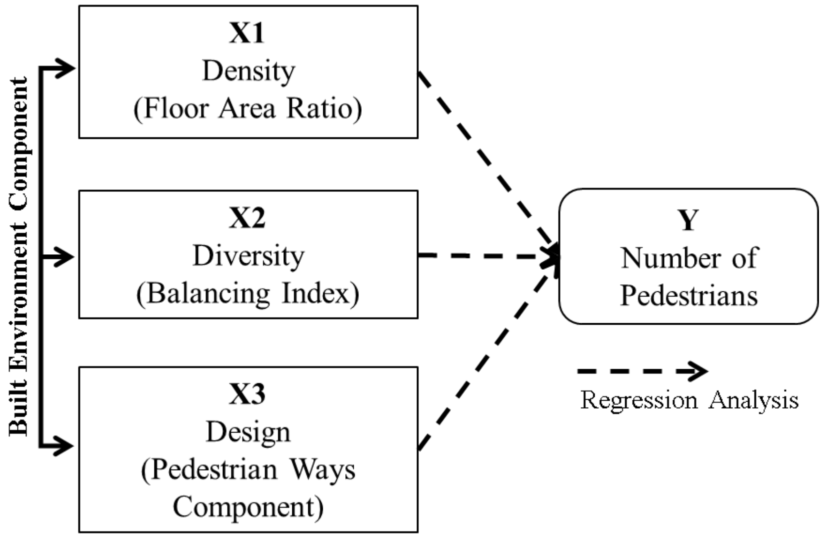


Figure 2. Linear regression analysis diagram

RESULT AND DISCUSSION

Density Analysis

Based on the comparative calculation between total population and land area in Semarang City, it was observed that, the highest population density occurred in the downtown vicinity, as shown in Figure 3. This is similar to the theory of urban growth in the world, which states that, the closer to the city centre, the higher the population density (Fee & Hartley, 2012). The high population density increases the demand for public transportation trips, such as, BRT, therefore, confirming the necessity to integrate services in areas with high density (Patankar et al., 2007). Furthermore, the implementation of the Bus Trans Semarang system has paid attention to this theory, as observed by all routes (I-VIII) passing through the city centre and the many bus-stops provided, as shown in Figure 3.

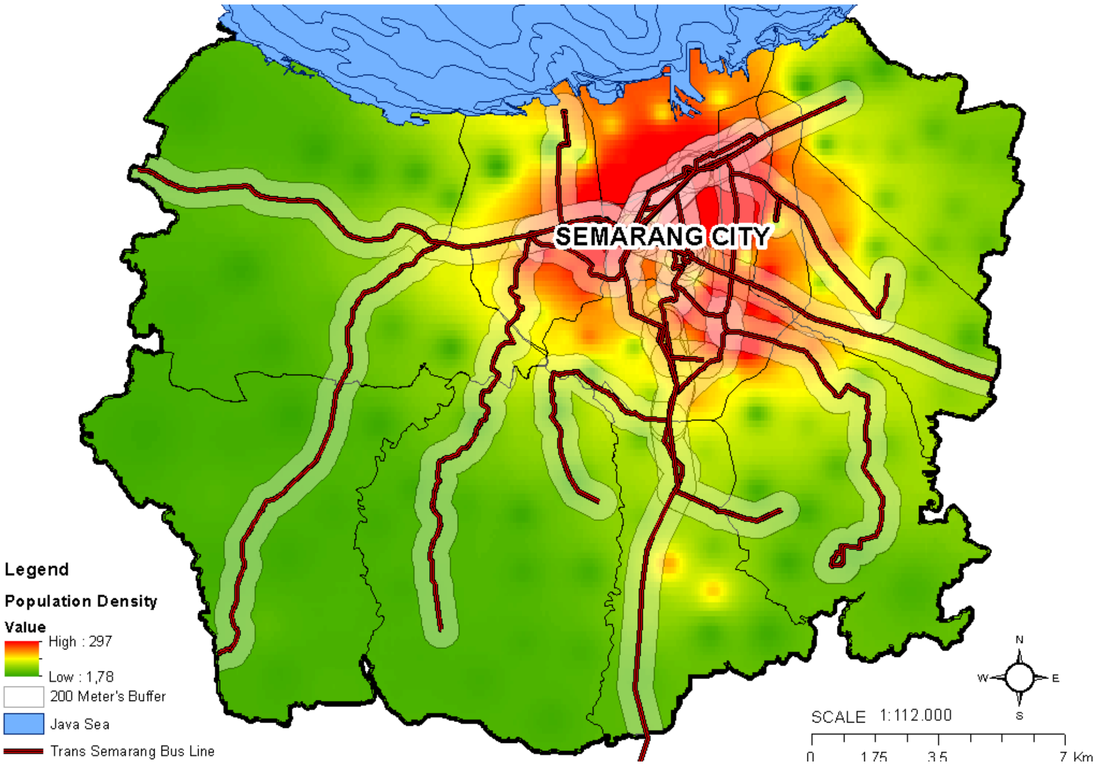


Figure 3. Population density in buffer area 200 meters from bus corridor

In addition, to calculating population density, the component was measured, by observing the quality of building. The calculation of density values in Table 2, indicated that, IIIB had the highest total, compared to other routes. The density that occurred in this corridor was dominated by 1-2 floors buildings, indicated by the low frequency value at 0.983. Data from the observations showed that, the entire Bus Trans Semarang corridor were dominated by developments in a horizontal direction and following the road network. The calculations in Table 2, regarding the element density conditions for each corridor showed that, out of the nine routes, only three had a relatively high frequency value (33%).

Furthermore, the research on transportation hubs in Japan found that, a high Floor Area Ratio (FAR) value, with optimized vertical building construction, improves land-use quality, while creating effective movement for pedestrians (Yang & Yao, 2009). High density areas with vertical buildings around them, minimized the use of motorized vehicle, and increased pedestrian intensity (Cervero & Kockelman, 1997; Monteiro & Campos, 2012; Zhang et al., 2016). Also, the density analysis results along the Bus Trans Semarang corridor, was contrary to that of the research conducted by Zhao et al. (2018), which found that, the dominance of density effect on the built environment and pedestrian activity in Beijing, belonged to a high category. This was in line with the Chinese government's regulation of intensifying vertical development, to implement a sustainable city development. This is different from the condition of existing regulation in Semarang, which has not emphasized on vertical building. However, an increase in vertical building growth is needed, especially in downtown areas, as regards the optimization of land-use, with the creation of a pedestrian-friendly, and sustainable transit-based transportation system.

Table 2
The condition of the element density of all corridor radius 200 meters (Total)

Corridor	Building				Lenght of corridor (Km)	Large of corridor (Ha)	Total Density (unit/Ha)	Density		
	1-2 floors (unit)	3-8 floors (unit)	>8 floors (unit)	Total (unit)				Low	Medium	High
(1)	(2)	(3)	(4)	(5)	(6)	200*(6) = (7)	(5)/(7)	(2)/(5)	(3)/(5)	(4)/(5)
I	4,358	290	8	4,656	60.0	1,200	4	0.897	0.096	0.007
II	3,833	130	3	3,966	26.5	530	7	0.960	0.043	0.001
IIIA	3,258	84	6	3,348	10.5	210	16	0.958	0.039	0.003
IIIB*	6,249	85	6	6,340	10.0	200	32	0.983	0.016	0.001
IV	714	167	21	902	22.3	446	2	0.758	0.172	0.028
V	968	152	18	1,138	25.9	518	2	0.817	0.164	0.039
VI	3,587	121	0	3,708	13.4	268	14	0.936	0.064	0.000
VII	654	110	2	766	6.9	138	6	0.824	0.149	0.002
VIII	171	96	7	274	22.4	448	1	0.632	0.341	0.027

*Note : *corridor with the highest density*

Diversity Analysis

The results of the equilibrium calculation in Table 3 showed that, the total balance index value of all the corridors is close to 1. The balance index value close to 1, was categorized as an area with mixed land-use possessing high parameters (Sung & Choi, 2013). The highest balancing index value, was in the Corridor II area. The result of the balancing index value in this corridor was 1.110, with trade and service centre as the main land-use. Its function as a centre for trade and services, has made this area experience increasingly diverse land-uses. The proportion of residential (60 hectares) and non-residential (59 hectares) land in this area is very stable, within a 200m radius from the transit centre. As one of the longest routes, Corridor I had the smallest balancing index value compared to others, which is only 0.395 (getting away from 1). The proportion of residential with non-residential land-use area in this corridor, is in the unbalanced category. Even, residential land reaches 98.70ha, while non-residential areas dominated by trade and services, offices, and industry, only had 40.22ha.

Table 3
Condition element diversity for all corridor radius 200 meters (Total)

Corridor	Res (Ha)	Non-res (Ha)	Balancing Index	Landuse
	(1)	(2)	(1)/(2) = (3)	(4)
I**	98.70	40.22	0.395	Settlements, industry, trade and services, warehousing, worship, defense and security, offices, education, health, recreation, public spaces, sports.
II*	60.59	58.72	1.110	Offices, trade and services, police education and sports, industry, and housing.
IIIA	64.58	89.44	0.831	Defense and security, education, health, offices, public spaces,
IIIB	56.55	23.04	1.184	recreation, settlements, trade and services, and worship.
IV	261.32	339.46	0.870	Offices, worship, health, trade and services, education, housing, recreation, defense and security, and transportation.
V	215.86	311.21	0.820	Education, health, industry, offices, defense and security, housing, sports, recreation, trade and services, and worship.
VI	57.68	31.10	1.314	Defense and security, education, health, offices, settlements, recreation, trade and services, and worship.
VII	129.01	247.47	0.685	Education, health, industry, offices, defense and security, housing, sports, recreation, trade and services, and worship.
VIII	158.80	167.19	0.938	Trade and services, worship, health, education, offices, recreation, defense and security, and settlements.

*Note : Res (Rsidential area), Non-res (Non-residential area): *corridor with the highest balancing index ; **corridor with the lowestt balancing index.*

In addition to the total calculation results as in Table III, the stop points with the highest balancing index value on each route are also explained. The aim is to serve as the main sample to show the spatial balancing index conditions through land use per building. The location of the highest balancing index for Corridor I, is the same as that of VIII, i.e., at the Amarta bus-stop point, as shown in Figure 5, section h. The balancing index value at this point is 1.10, which is dominated by non-residential land-use, as trade and services. The locations with the highest balancing index at the Corridor II area, is the City Hall bus-stop, which is shown in Figure 5, section a. The balancing index value at this point is 0.96, with the dominance of non-residential land-use in the form of, offices and educational buildings. However, for Corridor IIIA, the location with the highest balancing index value, is at the point of the Raden Patah bus-stop, as shown in Figure 5, section b. The balancing index value at this point is 1.06, with the dominance of non-residential land-use in the form of, trade and services with school buildings. The highest balancing index value for Corridor IIIB was located at the Don Bosco stopping point, as shown in Figure 5, section c, with a value of 1.06. The dominance of land-use in this corridor was the use of residential land, as housing and school buildings.

The location with the highest balancing index value is in the Corridor IV area, i.e., at the Nyaliyan Square bus-stop, as shown in Figure 5, section d, with a value of 0.99. The dominance of land use in this corridor, was the use of non-residential land as trade and services, with educational buildings. Furthermore, based on Figure 5, section e, in the Corridor V area, the highest balancing index value is at the Karang Ayu bus-stop point with 1.00 (very balanced). The dominance in this corridor is a land-use Settlement. The location with the highest balancing index value in Corridor VI, is at the Diponegoro University Nursing bus-stop (educational area), with a value of 1.04. Based on Figure 5, section f, it was shown that, the dominance of non-residential land-use in this area, is in the form of educational buildings. Also, for the highest balancing index, Corridor VII is located at the Petek bus-stop, as shown in Figure 5, section g. The balancing index value at this point is 0.99, with the dominance of non-residential land use, in the form of trade and services.

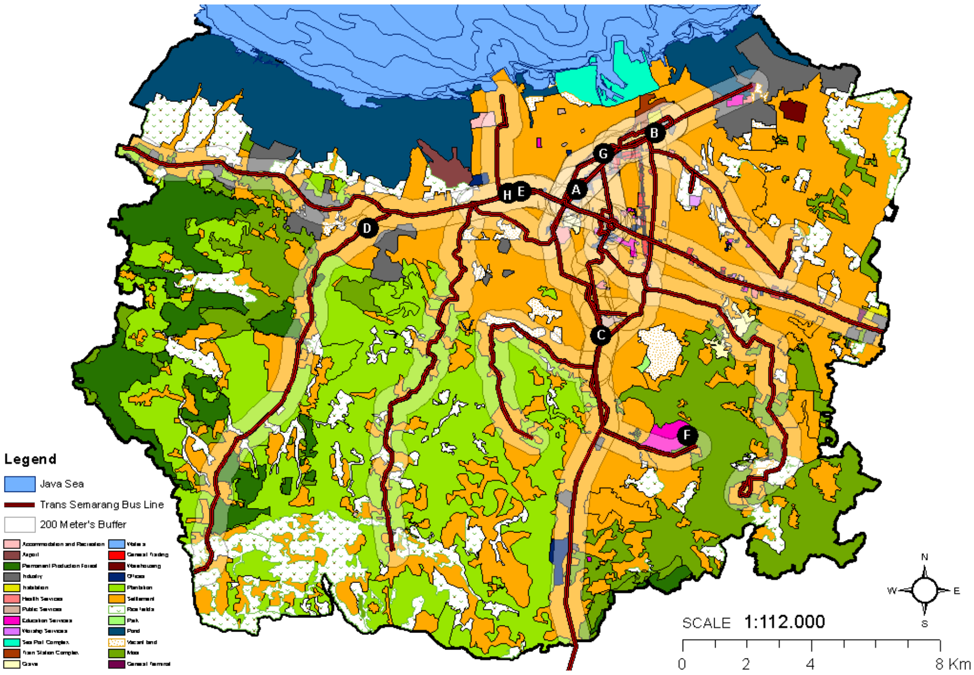


Figure 4. Distribution of land use and location of balancing index sample points in Semarang City.

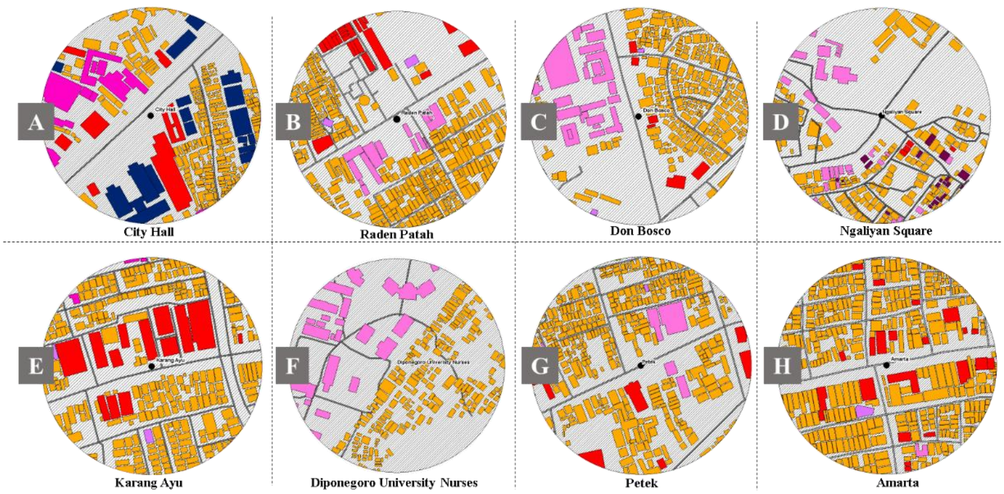


Figure 5. Land use corridor and highest balancing index value (200 meters) ; (A) Corridor II, (B) Corridor IIIA, (C) Corridor IIIB, (D) Corridor IV, (E) Corridor V, (F) Corridor VI, (G) Corridor VII, (H) Corridor I & VIII.

The diversity analysis results for all Bus Trans Semarang corridors had the same pattern of balance index. The locations with the highest balancing index values,were dominated by land-use for education, trade and services. Some studies stated, that commercial land-uses (educational with trade and services) can increase people interest in walking activity, within the area (Miranda-Morenoa et al., 2011; Townsend & Zacharias, 2010; Chalermpong, 2007). Based on field observations, activities in the area of education, trade and services are only active in the morning and evening, especially on weekdays (Monday-Friday), pedestrian walkways are rarely used during holidays. Furthermore, there needs to be an increase in attractions, in order to bring in and improve activities, therefore, allowing public facilities such as, pedestrian walkway, to function optimally. The areas with mixed land-use characteristics on foot are more attractive, because, the resulting movements are more diverse (Untermann et al., 1984). Therefore, various types of land-use are needed to improve population activities' pattern, in order to optimize the usage of space, and create a sustainable pedestrian walkways system.

Design Analysis

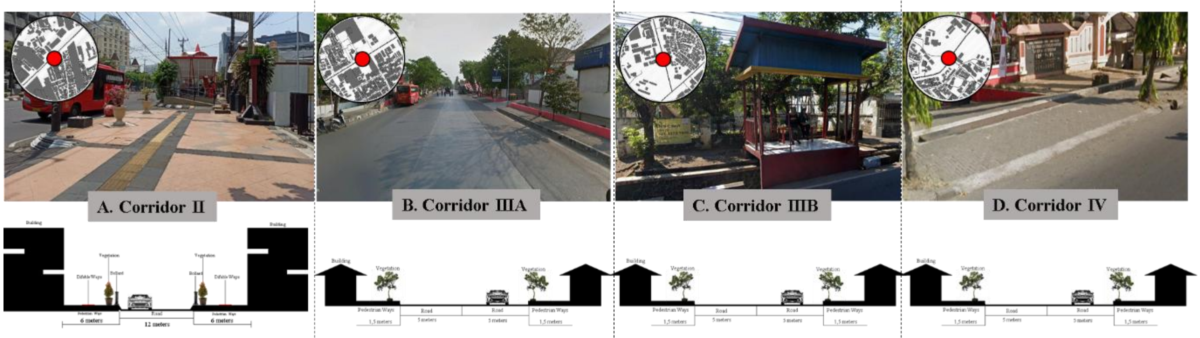
Based on the pedestrian walkways design analysis, the results showed that Corridors IV, I, and II, are routes with the largest number of inclines, crossings, and irregularities, compared to other route, as shown in Table 4. Compared with the pedestrian data in Table 1, has produced a linear pattern toward pedestrian walkway facilities. Corridors with the highest number of pedestrians, tend to have more complete walker facilities. Another indication was that, the closer to the city centre with a denser population activity level, the better and more complete the pedestrian walkways design' facilities becomes. Some locations in areas that far from the city centre, such as traversed by Corridor VI, had pedestrian walkways with a width of 1m-2m, and are only equipped with vegetation, as shown in Table 4 and Figure 6.

Table 4
Complete pedestrian walkways design for the Bus Trans Semarang corridor radius 200 meters (Total)

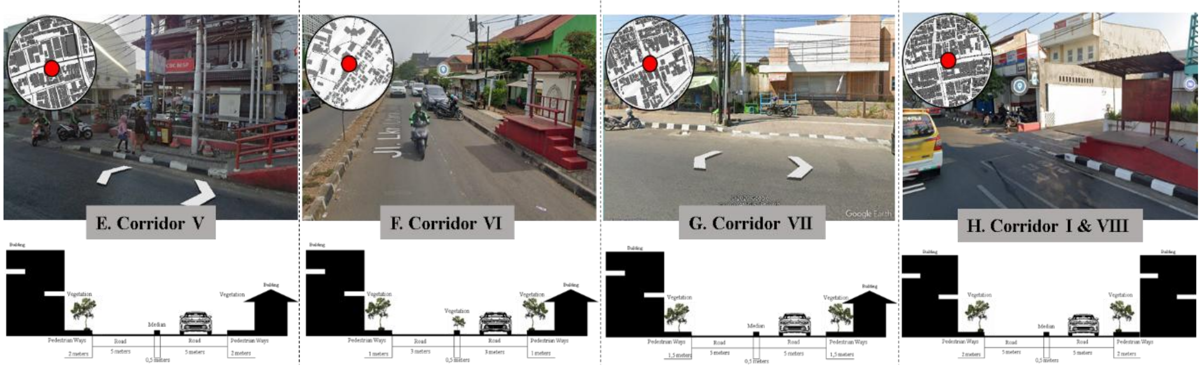
Corridor	Pedestrian walkways Large (m)	Lanes of the road	Number of			Street Furniture
			Inter sections	Ramp	Crossings	
I*	1-5	2 – 6	172	267	42	Shade vegetation, bollards, lights, trash cans, traffic signs, seats, special lanes for the disabled.
II*	1-5	2	165	138	38	Traffic signs (no stopping sign, no parking), street lights, ways with disabilities, and potted vegetation.

Corridor	Pedestrian walkways Large (m)	Lanes of the road	Number of			Street Furniture
			Inter sections	Ramp	Crossings	
IIIA	1-5	1 - 2	95	3	13	Lights, bollards, vegetation, traffic signs, trash cans, fire hydrants.
IIIB	1-1.5	1 - 2	246	0	22	Shade vegetation, and traffic signs.
IV*	1-3	2 - 4	110	396	30	Shade vegetation, bollards, lights, traffic signs, and special lanes for the disabled.
V	0.5-2.5	1 - 2	170	27	31	Shade vegetation, lights, traffic signs, benches, and special lanes for people with disabilities.
VI	1-3	2	132	40	18	Traffic lights and signs.
VII	1-2.5	1 - 2	127	21	12	Shade vegetation, lights, traffic signs, and ways for the disabled.
VIII	1-3	2 - 6	24	184	16	Shade vegetation, special lanes for people with disabilities, and traffic signs.

Note : corridor with the most complete design elements



(a) Sample of pedestrian walkways ; corridor II, corridor IIIA, corridor IIIB, dan corridor IV.



(b) Sample of pedestrian walkways ; corridor V, corridor VI, corridor VII, and corridor VIII.

Figure 6. Pedestrian walkways conditions throughout the Bus Trans Semarang corridor

The sidewalks along the Bus Trans Semarang corridor still needs improvement, because, there is a gap between the current condition and user needs. The region's undulating topography and climatic conditions, means that the average walking distance in Semarang City, is only 200m-250m. Completeness design components and city environmental conditions of pedestrian walkways, increases people's tendency in walking to and from a destination (Özbil et al., 2015). Completeness of pedestrian walkways such as, ramps, sidewalks, vegetation, and many more, affects walking activities, when working or not (Dixon, 1996; Munshi, 2016). However, as a country with a tropical climate and year-round sunshine, was an impact of the lack of comfort in outdoor activities, such as walking. Furthermore, there has to be a need for climate adjustments, by providing vegetation as shade, which is well applied to four-seasoned countries, such as, Montreal, Canada (Miranda-Morenoa, 2011). The existence of vegetation at the same time can produce sufficient oxygen and reduce carbon dioxide that produced by motorized pollution. Therefore, it is necessary to have a pedestrian walkway with complete facilities, and focus on both environmental and climatic conditions, in order to realize a sustainable transportation system.

The Built Environment Model that Affects Pedestrians

Based on the linear regression test results, the partial coefficient T-test method was used, to determine the relationship significance, between two or more variables. In this method, two things were used as benchmarks, i.e., the coefficient T and the significant results. The dependent variable was the number of pedestrian passengers of the Bus Trans Semarang per corridor (Y), with built environment as the independent variables, namely, the total density (X1), balancing index diversity (X2), and the number of walkway design elements (X3), in a radius of 200 from corridors. Based on Table 5, which was about the results of linear regression data processing (coefficient T-test), the T-value of density (X1) 0.454 and significance value of 0.669 (>0.05) were obtained. This mean that, the density (X1) does not significantly influence the pedestrian intensity (Y), because of the calculated T-value being less than the T-table (2.353), with that of the significance greater than 0.05.

Furthermore, based on the same table, it was shown that diversity (X2) had a coefficient T-value of 7.028 (> 2.353), and a significance calculated value of 0.001 (<0.05). This results, indicated a significant relationship between the pedestrian intensity (Y) and diversity (X2). The independent variable (diversity), was observed to affect the intensity of pedestrians at the research location, with a direction of positive influence, i.e., the more balanced land-use in an area, the more the frequency of a person to take a walk. Based on the same table, it was shown that, design (X3) does not have a significant relationship with the pedestrian intensity (Y). This was because, the variables had a calculated T-value of 1.624, which is smaller than the T-table (2.353), with the calculation of significance greater than the standard of tolerance (> 0.05).

Table 5

The results of data processing linear regression (partial T-test) SPSS

Code	Independent Variable	Unstandardized B	T*	Sig**
Coeficient		2.630		
X1	Density (Floor Area Ratio calculation results)	0.011	0.454	0.669
X2	Diversity (The ratio of residential and non-residential land or Balancing Index)	2.172	7.028	0.001
X3	Design (The completeness of the pedestrian walkways elements)	0.000	1.624	0.165

*Note : The F table value is 2.35: *If T count> T the data table has a close relationship; **Sig <0.05 has a significant relationship meaning.*

Based on the results of the linear regression model in equation 6, it was shown that, the diversity variable had a positive effect on the frequency of pedestrians. The higher the level of balancing index in an area, the more the number of pedestrians increase. However, when the probability of diversity (balancing index) increases by 2.172, the frequency of pedestrians rises by 2.630million in a year (see equ 6).

$$Y = 2.630 + 2.172 \text{ x } 2 \quad [6]$$

The results of this study, are similar to the research conducted in the City of Montreal, Canada. The results suggested that, land diversity influences a person's tendency to walk around the transit centre (Miranda-Morenoa et al., 2011). As with Montreal, land-use as a centre for trade and services with school buildings, dominated the goals of pedestrian movements. Similarly, the research results in Bangkok stated that, the use of commercial land, tends to encourage people to walk around transit centres (Townsend & Zacharias, 2010; Chalermpong, 2007). The environmental conditions along the transit-based transportation routes in Bangkok City, had the closest characteristics to this research. The characteristics of building density and land-use were relatively spread out, from the city centre to the suburbs. Furthermore, another similarity included, the provision of pedestrian walkways' facilities not being optimal. The difference between the study results and previous researches, depends on the coverage of the research area, topographical conditions, and urban development policies. Montreal and Beijing city, tends to influence the density component on a person's frequency to walk, because of the flat topography, supporting vertical development policies, and the relatively close distance between buildings and transit centres. Also, the pedestrian design elements in these areas are relatively complete, when compared to Semarang and Bangkok City of Thailand. The following is a diagram of the resulting model in Figure 7.

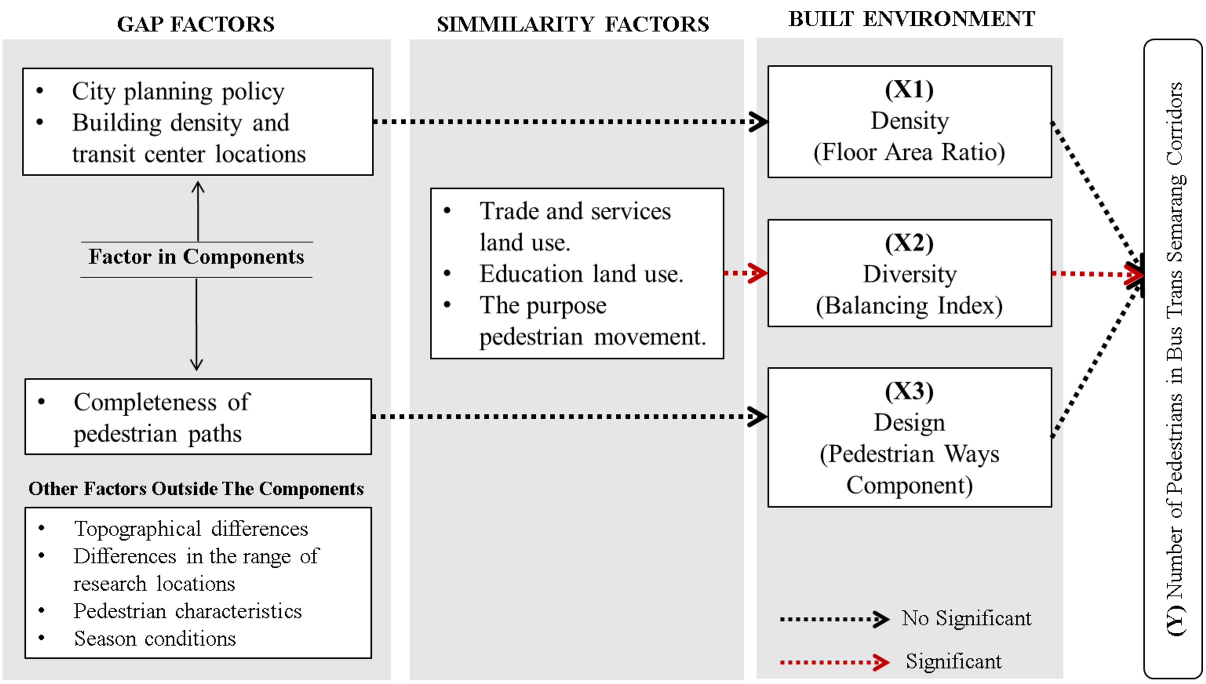


Figure 7. Model diagram for influence analysis of the built environment on pedestrian activity.

CONCLUSION

The analysis results showed that, the diversity component is a feature of the built environment, which significantly influences people's frequency to walk along the Bus Trans Semarang. The diversity conditions around pedestrian walkways in Semarang City, showed a high balancing index between residential and non-residential land-uses. Also, the domination of commercial land-use, was in the form of trade, education, and service areas. Furthermore, the high mixed land-use areas tends to affect people's frequency to walk, because the activity patterns are more diverse. The results of the model showed that, there is a positive relationship between the diversity variable, and the frequency of pedestrians, which further indicated that, the higher the level of balancing index, the increase in walkers' frequency.

However, the two other components, such as density and design, did not influence a person's frequency to walk. Also, because the optimization of the vertical development is still very minimal, the distance between buildings tend to be far apart. The lack of availability of pedestrian facilities, along the Bus Trans Semarang corridor, especially in the city centre area, were also part of the reasons these two built environment components (density and design) were not able to influence the frequency to walk, in the city of Semarang. Also, it is feared that this issue does affect a person's desire to use transit-based transportation, such as the Bus Trans Semarang. Therefore, it is expected that, follow-up measure is made available, to adjust pedestrians' demands with the built environment, along the Bus Trans Semarang corridor, in order to create a sustainable transportation system.

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The Built Environment and its Impact on Transit Based Transportation Users Walking Activity in Semarang, Indonesia

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ABSTRACT

The increase in mobility rate due to the current rise in population has become a challenge in urban development. This led to the development of pedestrian walkways, which are integrated with transit-based transportation, to minimize problems due to the high level of mobility of the urban population. According to some experts, environmental conditions are one of the main factors capable of affecting pedestrians' frequency. Therefore, this study explores the effect of the built environment, such as density, diversity, and design, on the pedestrian frequency of the Bus Trans Semarang passengers. Data were collected from 9 corridors, consisting of 447 bus stops, directly connected to the pedestrian walkways, as one of the feeders for transit-based transportation facilities. The analysis method used for each variable was the formulation technique, with data simulated using various applications, such as ArcGIS. The linear regression partial t-test model was also analyzed using SPSS, with the effect of pedestrian frequency on dependent variables determined, using the built environment elements (independent variable). The results showed a positive significance between the diversity variable and pedestrians' frequency along the Bus Trans Semarang corridors. Furthermore, the land that varies with the dominance of commercial and educational area has the highest attraction features that affects a person's frequency to walk.

Keywords: Built environment, pedestrian walkways, transit-based transportation

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INTRODUCTION

The development of a transit-based transportation system is intensively carried out as an alternative means of private transportation to overcoming population growth in various countries. According to Makarova et al. (2017), the Asian region is generally known for its unhealthy transportation system, which causes various problems, such as congestion, air pollution, and sprawl-related issues (Makarova et al., 2017). Therefore, to overcome this, the World Health Organization (WHO) encourages countries to implement sustainable transportation systems that focus on safe, efficient, accessible, affordable, inclusive, green, and healthy transportational mobility.

A Transit-Oriented Development (TOD) is a form of sustainable transportation that emphasizes integrating urban spatial design to unite people, activities, buildings, and public spaces through connectivity, accessible by walking (ITDP, 2017). Increasing walking intensity (walkability) is considered part of the effective solutions in overcoming unhealthy transportation because it minimizes congestion, increases environmental sustainability, encourages physical activity, improves public health, and enhances urban settlements' appropriateness (Blanco & Alberti, 2009). The pedestrian walkways, commonly referred to as a sidewalk in a transit-based transportation system, is a facility feeder that connects a transit centre with other activity functions (Hu et al., 2013). However, the lack of optimal pedestrian walkways is a challenge for establishing a sustainable transportation system in several countries.

Various studies suggested that the optimization of pedestrian walkways, such as the completeness of design components, an attractive, safe, and comfortable city shape increases residents' tendency to walk to a destination (Özbil et al., 2015). Furthermore, the developments of a land-use planning, and urban design are crucial in increasing pedestrian activity in cities (Timmermans, 2009). However, research on the relationship between the conditions of the built environment, and walking tendency in the transit-based transportation system is rare. Various parties have been inclined to focus on increasing the transportation system’s capacity, without observing how the developments affect the environment. Therefore, the development of a new transportation system is linear with the uneven distribution of building density and land-use management, thereby leading to inadequate functioning of several pedestrian walkways.

The built-environment is a transit-based transportation system commonly found in European countries. The initial milestone associated with this technique was first carried out by Cervero & Kockelman (1997) in the European countries to welcome new urbanism concepts. According to them, the built environment means physical features of the urban landscape (i.e., alterations to the natural landscape). These authors formulate three main components to assess the built environment from the same source, namely density, diversity, and design.

The density is defined as the component produced by observing population frequency per household and building quality per area (Cervero & Kockelman, 1997; Monteiro & Campos, 2012; Zhang et al., 2016). Furthermore, this research and the pedestrian activity in previous studies observed that the areas with a high-density level are associated with walking (Oktaviani et al., 2020). A study carried out by Duduta (2013) developed indicators for assessing density components in constructing measurements, which are properly related to building height or the Floor Area Ratio (FAR) analysis method. The study takes a minimum distance of 200m from the stop point, which was recorded, and divided into three categories of level assessment, namely low (1-2 floors), medium (3-8 floors), and high (>8 floors) densities.

The diversity component is represented as a land-use balancing index used to compare the ratio of residential and non-residential (commercial) areas. According to Sung et al. (2013), the level of balancing land-use in an area rises, the activities of pedestrians relatively increased. Furthermore, by simplifying Cervero and Kockelman (1997) research, the diversity component emphasizes the calculation model of residential and non-residential land area ratios, which in this case, is measured by the balancing index formula (Sung et al., 2013). The diversity variable analysis results show the patterns of land use and its changes due to population mobility. Several studies, such as those carried out by Cervero, found that the effects of diversity have long been ignored.

The design component is part of the features referring to the assessment of pedestrian walkways and its integration with the road network system (Dixon, 1996; Munshi, 2016). Similar to diversity, the effects of design also have long been ignored in built environment analysis. However, the design component's measurement is more complicated than density and diversity, with a system of assessing pedestrian walkway completeness elements adjusted to environmental conditions (Zhang et al., 2016). Therefore, this study summarized the design indicators needed to identify the appropriate pedestrian walkways at the research location. This includes the lane width, route count, road intersection number, the presence of ramps, bridges, zebra crossings, and the completeness of street furniture.

The country context plays an essential role in ascertaining the built environment assessment of pedestrian activities. The biggest question that emerged from previous research is whether the context of the European region's built environment is similar to the Asian zone. Furthermore, a research in downtown Montreal, Canada showed that the components of the built environment, density (population, number of jobs, schools, and bus stops), diversity (commercial land use), and design (percentage of main arteries, average length of roads), affected pedestrian activity (Miranda-Morenoa et al., 2011). This city's position in Canada is a provincial capital not included in the national central area. It is observed to be a part of the cities located in developed countries. In this location, the problem encountered was a lack of pedestrians' security on the walkways. However, this location had a complete pedestrian walkways element, surrounding skyscrapers. As a four-season country, the provision of vegetation along the pedestrian walkways in the city is designed to suit seasonal conditions. This is because the designs that adapt to climate change and periods are being intensified to create sustainable urban life.

The discussion of the built environment, on pedestrian walkways in developing countries, for example, the transit area in Bangkok, Thailand, was developed from an interplay between people's tendency to walk and the diversity of land-use around the transit area (Townsend & Zacharias, 2010). The walkways condition in Bangkok, Thailand, is associated with air pollution and lack of sidewalks (Townsend & Zacharias, 2010; Chalermpong, 2007). Therefore, from this study, it is obtained that the development of commercial, retail, and residential land is relatively high around the transit centre, which shows that the influence of diversity is high on pedestrian movement patterns.

The research carried out in other Asian regions, such as Beijing, China, obtained different results. According to Zhao et al. (2018), the findings on the built environment at the environmental-scale transit centres in Beijing, show that the density component plays a substantial role in influencing pedestrian activities. The study showed that the pedestrian walkway components in Indonesia was complete compared to those in Bangkok. Also, the influence of the vertical building construction policy in the central area of Beijing City is the basis for forming a compact area, with relatively close distances between buildings. Based on that statement, the density of the built environment in this area influences a person's inclination to walk. Therefore, the geographic characteristics with the research's scope carried out in Bangkok and Beijing relatively similar. This is because they are often conducted in locations with relatively flat homogeneous topography, using city-scale research coverage.

Semarang is one of the major cities in Indonesia, located in Central Java Province. The city intensively plans to develop a Transit Oriented Development (TOD) system, accommodate the community's mobility needs, and create a sustainable transportation channel. The requirement needed for the development of the TOD system in this city is the Bus Trans Semarang. The relationship between the built environment and pedestrian activities in the central transit area, along the Bus Trans Semarang corridor, seems interesting because it covers the city centre area with a diverse topography in its surroundings. The problem of pedestrian walkways provision in Semarang City is the same as that of Bangkok, which is associated with pollution related-issues, and lack of sidewalks. Based on further data, it was observed that approximately 88% of Bus Trans Semarang passengers walked to or from the bus stops (Purwanto & Manullang, 2018). This result is certainly in contrast to the lack of pedestrian walkways provision in the city of Semarang, which then causes a gap between availability and demand.

Policies regarding land-use, regulated by City Territory Section (CTS), indicated that Semarang City's use is very diverse. Furthermore, the absence of a firm policy on building construction efforts has led to a high sprawl level in this area. Therefore, this study aims to ascertain the best-built environment model, which affects a person's tendency to walk along the Bus Trans Semarang corridor, from the city centre to the suburbs. It also complements previous research that only focused on density conditions in the built environment analysis. This research is further accompanied with a question, such as, ‘Do the built environment components affect the pedestrian activity of transit-based transportation users in Semarang City?’

METHODS

Semarang Study Area

Semarang City is one of the metropolitan cities in Indonesia, located in Central Java Province, with a population of 1.79 million people. According to the data obtained from the Semarang City Statistics Centre in 2019, the population of this area keeps increasing by 50% yearly, accompanied by the provision of a non-optimal public transportation system. This location is one of the pilot project for Bus Rapid Transit (BRT) development in Indonesia, with the provision of Bus Trans Semarang in 2009, to help improve the quality of transportation system (SuaraMerdeka, 2015).

Therefore, this research covers all Bus Trans Semarang routes, consisting of, Corridors I, II, IIIA, IIIB, IV, V, VI, VII, and VIII, as shown in Figure 1. According to Kim et al. (2018), two methods are used to measure the built environment, based on the area's scope, namely, the street level of 50m and the neighborhood position at a maximum radius of 400m, from the observation point. The data showed that the maximum distance for walking in Semarang City was only 200m-250m between destination locations (Purwanto & Manullang, 2018). Therefore, sampling of the observation area, using the neighbourhood level method, with a radius of 200m from the right and left of the road was carried out in this research.

In this study, the entire Bus Trans Semarang corridor has 596 bus-stops, scattered from the city centre to the suburbs, while also connecting various important land-uses, such as terminals, government areas, education fields, and many more, as shown in Table 1. Data from the Semarang City Transportation Office in 2018 showed a significant increase in Bus Trans Semarang passengers from 2010-2018. The total number of passengers between 2010 and 2018 were 369,326 and 10,210,296, respectively. Furthermore, the largest contributor for pedestrians in this study was Corridor I, which had massive bus-stops and fleets compared to the other eight corridors. Based on the data collected from the field observations, pedestrian activities along the Bus Trans Semarang corridor were dominated by school, work, and recreational activities. City centre areas such as Corridors I, II, and IV, had more massive pedestrian activities than other zones.

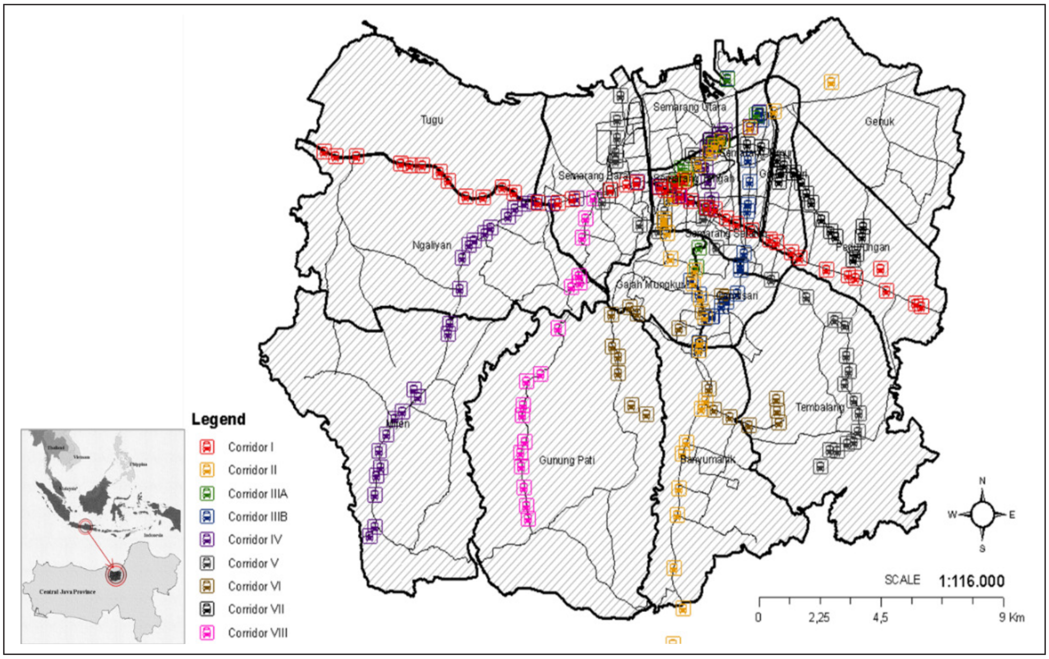

Figure 1. Bus Trans Semarang stops in the study area

Table 1
Bus Trans Semarang corridor profile

Corridor	Rute	Number of			Corridor Length (Km)	Operating Years
		Pedestrian (People)	Bus (Unit)	Stops (Unit)		
I*	Mangkang Terminal→Penggaron Terminal.	2,713,852	25	81	60.0	2009
II	Terboyo Terminal→Sisemut Terminal.	838,081	34	74	26.5	2012
IIIA	Tanjung Emas Port→KagokTanjung Emas Port.	166,934	16	45	10.5	2014
IIIB	Tanjung Emas Port→Elizabeth Hospital→Tanjung Emas Port.	111,289		40	10.0	2014
IV	Cangkiran Terminal →Semarang Tawang Station.	520,436	22	87	22.3	2013
V	Meteseh Residential AreaAirport→Marina Beach.	366,319	16	75	25.9	2017
VI	Diponegoro University→Semarang State University.	257,831	16	63	13.4	2017
VII	Terboyo Terminal→Semarang City Hall.	87,886	13	63	6.9	2018
VIII	Cangkiran Terminal→Simpang Lima (City Center).	56,799	20	68	22.4	2019

Note. *corridors with the most pedestrians

Quantitative Analysis

This research utilized the quantitative research technique, which focused on analyzing the built environment in the form of density, diversity, and design. Data was collected through naturalistic direct field observation methods. Furthermore, the density analysis assessed the population frequency by comparing the total populace, using the interpolation method (ArcGIS 10.3). This analysis produced a spatial picture of population density in each Corridor. Also, the density component analysis used the numerical calculation method, such as the Floor Area Ratio (FAR), to compare the number of buildings per floor area. The calculations in accordance with Duduta's (2013) research, were divided into three categories, namely low (Equation 1), medium (Equation 2), and high (Equation 3) densities, as shown in Equation 1-3.

$$\text{Low density} = \frac{\text{number of buildings } 1-2 \text{ floors}}{\text{the total number of buildings within a 200 meter radius of the stop point}} \quad [1]$$

$$\text{Medium density} = \frac{\text{number of buildings } 3-8 \text{ floors}}{\text{the total number of buildings within a 200 meter radius of the stop point}} \quad [2]$$

$$\text{High density} = \frac{\text{number of buildings } >8 \text{ floors}}{\text{the total number of buildings within a 200 meter radius of the stop point}} \quad [3]$$

Diversity components were analyzed, using the land-use ratio analysis, while comparing the residential, commercial, office space, public services, and recreational areas, to the total space around the Bus Trans Semarang bus-stop, in each Corridor. According to Sung et al. (2013), this diversity of land-use is used to compare the residential and non-residential areas, using the balancing index (RNR) formula, as shown in Equation 4.

$$\text{RNRi} = 1 - \left[\frac{\text{Res} - \text{Non res}}{\text{Res} + \text{Non res}}\right] \rightarrow \text{The closer to 1, the more balance} \quad [4]$$

The design component was carried out by analyzing the road structure and pedestrian walkways' completeness features, based on movement needs. In this case, the assessment indicators were completeness elements, which include crossings, ramps, intersections, lane width, number of routes, and sidewalk furniture. The analysis of this component was presented to visualize the existing conditions, which were compared with the required pedestrian feature demand data, in Semarang. Further, the overall results of the density, diversity, and design analysis were processed, using the significance of linear regression (partial T-test) and the SPSS Statistics 24 application, to determine the effect of the built environment on walking activities in each Corridor. The model formula used in determining the influence between the variables is shown in Equation 5.

$$Y = a + b(X) \quad [5]$$

Where;
Y = frequency of pedestrians (person)
a = constant
b = coefficient
X = built environment variables

Linear regression had been widely used in previous studies to produce a relationship model between the built environment variables and pedestrian movement patterns in an area. The requirements of linear regression analysis (partial T-test) is that when the results of the coefficients (t) are greater than the t-table (2.35), with the regression data's significant value less than 0.05 (<0.05), then both variables (dependent & independent), influences each other. The built environment variable consists of density (X1), diversity (X2), and design (X3) as independent variables, which correlates with the pedestrian intensity in each Corridor (Y), as shown in Figure 2.

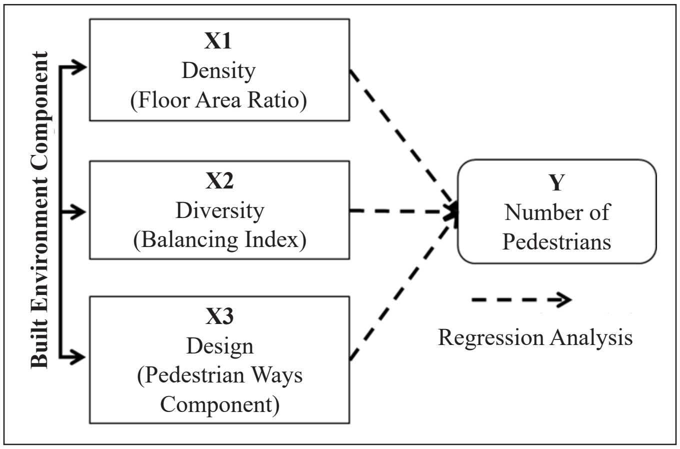

Figure 2. Linear regression analysis diagram

RESULT AND DISCUSSION

Density Analysis

Based on the comparative calculation between total population and land area in Semarang City, the highest population density was observed to occur in the downtown vicinity (Figure 3). This is similar to the theory of urban growth in the world, stating "the closer to the city centre, the higher the population density" (Fee & Hartley, 2011). The high population density increases the demand for public transportation, including BRT, therefore, confirming the need to integrate services in areas with high density (Patankar et al., 2007). Figure 3

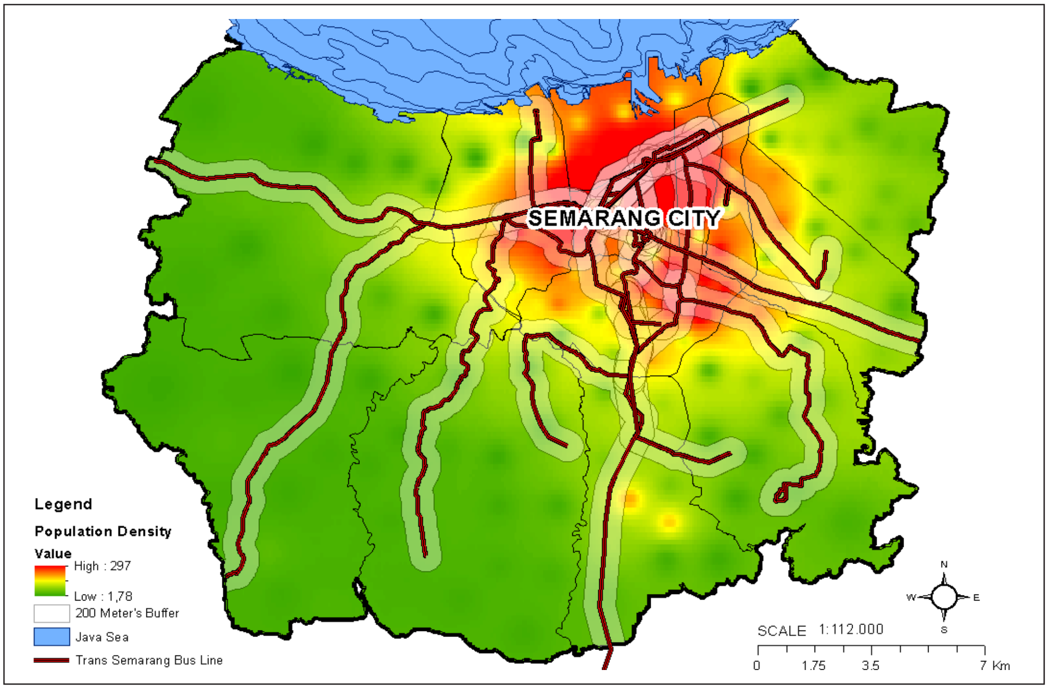

Figure 3: The population density in buffer area, 200 meters from bus corridor

shows the implementation of the Bus Trans Semarang system has paid attention to this theory, as observed in all routes (I-VIII) passing through the city centre and numerous bus-stops provided.

In addition to calculating population density, the component was measured by observing the quality of building. Table 2 shows the calculation of density values, with IIIB having the highest total, compared to other routes. The density in this corridor was dominated by 1-2 floor buildings, indicated by the low frequency of 0.983. Meanwhile, data from the observations showed the entire Bus Trans Semarang corridor were dominated by developments in a horizontal direction and following the road network. According to Table 2, with regard to the element density conditions for each corridor, only three out of nine routes had a relatively high frequency value (33%).

Furthermore, the research on transportation hubs in Japan discovered a high Floor Area Ratio (FAR) with optimized vertical building construction, improves land-use quality, while creating effective movement for pedestrians (Yang & Yao, 2019). Thus, high density areas surrounded by vertical buildings, minimized the use of motorized vehicle and increased pedestrian intensity (Cervero & Kockelman, 1997; Monteiro & Campos, 2012; Zhang et al., 2016). Also, the density analysis along the Bus Trans Semarang corridor, produced results contrary to the study by Zhao et al. (2018), stating the dominance of density effect on the built environment and pedestrian activity in Beijing was high. This was in line with

Table 2
The condition of the element density of all corridor radius 200 meters (Total)

Corridor	Building				Lenght of corridor (Km)	Large of corridor (Ha)	Total Density (unit/ Ha)	Density		
	1-2 floors (unit)	3-8 floors (unit)	>8 floors (unit)	Total (unit)				Low	Medium	High
(1)	(2)	(3)	(4)	(5)	(6)	200*(6) = (7)	(5)/(7)	(2)/(5)	(3)/(5)	(4)/(5)
I	4,358	290	8	4,656	60.0	1,200	4	0.897	0.096	0.007
II	3,833	130	3	3,966	26.5	530	7	0.960	0.043	0.001
IIIA	3,258	84	6	3,348	10.5	210	16	0.958	0.039	0.003
IIIB*	6,249	85	6	6,340	10.0	200	32	0.983	0.016	0.001
IV	714	167	21	902	22.3	446	2	0.758	0.172	0.028
V	968	152	18	1,138	25.9	518	2	0.817	0.164	0.039
VI	3,587	121	0	3,708	13.4	268	14	0.936	0.064	0.000
VII	654	110	2	766	6.9	138	6	0.824	0.149	0.002
VIII	171	96	7	274	22.4	448	1	0.632	0.341	0.027

Note. *corridor with the highest density

the Chinese government's regulation of intensifying vertical development, to implement a sustainable city development, and is different from the existing regulation condition in Semarang, with no emphasis on vertical building. However, increased vertical building growth is required, especially in downtown areas, in terms of land-use optimization, with the creation of a pedestrian-friendly and sustainable transit-based transportation system.

Diversity Analysis

Table 3 shows the equilibrium calculation results, with the total balance index of all the corridors close to 1, thus, categorized as areas with mixed land-use, possessing high parameters (Sung et al., 2013). Furthermore, the highest balancing index of 1.110, was obtained in the Corridor II area, with trade and service centre as the mainland-use. The area’s function as a centre for trade and services, has led to increasingly diverse land-use, and the proportion of residential (60 hectares) to non-residential (59 hectares) land in the area is very stable within a 200m radius, from the transit centre. As one of the longest routes, Corridor I had the smallest balancing index of 0.395 (getting away from 1). In this corridor, the proportion of residential to non-residential land-use area is unbalanced. The residential land amounts to 98.70ha, while non-residential areas dominated by trade and services, offices, and industry, was only 40.22ha.

In addition to the total calculation results, the table above also explains the stop points with the highest balancing index value on each route. This aims to serve as the main sample, showing the spatial balancing index conditions through land use, per building. In general, Figure 4 explains the position of the balancing index sample point for each

Table 3
Condition element diversity for all corridor radius 200 meters (Total)

Corridor	Res (Ha)	Non-res (Ha)	Balancing Index	Landuse
	(1)	(2)	(1)/(2) = (3)	(4)
I**	98.70	40.22	0.395	Settlements, industry, trade and services, warehousing, worship, defense and security, offices, education, health, recreation, public spaces, sports.
II*	60.59	58.72	1.110	Offices, trade and services, police education and sports, industry, and housing.
IIIA	64.58	89.44	0.831	Defense and security, education, health, offices, public spaces, recreation, settlements, trade and services, and worship.
IIIB	56.55	23.04	1.184	
IV	261.32	339.46	0.870	Offices, worship, health, trade and services, education, housing, recreation, defense and security, and transportation.
V	215.86	311.21	0.820	Education, health, industry, offices, defense and security, housing, sports, recreation, trade and services, and worship.
VI	57.68	31.10	1.314	Defense and security, education, health, offices, settlements, recreation, trade and services, and worship.
VII	129.01	247.47	0.685	Education, health, industry, offices, defense and security, housing, sports, recreation, trade and services, and worship.
VIII	158.80	167.19	0.938	Trade and services, worship, health, education, offices, recreation, defense and security, and settlements.

Note. Res (Rsidential area), Non-res (Non-residential area): *corridor with the highest balancing index; **corridor with the lowest balancing index

corridor on the distribution of land use in Semarang City. Meanwhile, Figure 5, section H shows the location of the highest balancing index for Corridor I is the same with VIII, at the Amarta bus-stop point, with a value of 1.10, and dominated by non-residential land-use, including trade and services. Meanwhile, Figure 5, section A show the location with the highest balancing index for Corridor II area is the City Hall bus-stop, with a value of 0.96, and dominated by non-residential land-use, in the form of offices as well as educational buildings. Figure 5, section B shows the location with the highest balancing index on Corridor IIIA is the Raden Patah bus-stop point, with a value of 1.06, and dominated by non-residential land-use in the form of trade as well as services, with school buildings. However, Figure 5, section C shows the highest balancing index for Corridor IIIB was located at the Don Bosco stopping point, with a value of 1.06, and dominated by residential land use, including housing and school buildings.

Furthermore, Figure 5, section D shows the location with the highest balancing index in the Corridor IV area is Nyaliyan Square bus-stop, with a value of 0.99, and dominated by non-residential land use, in the form of trade as well as services, with educational buildings. Meanwhile, Figure 5, section E shows the highest balancing index in Corridor

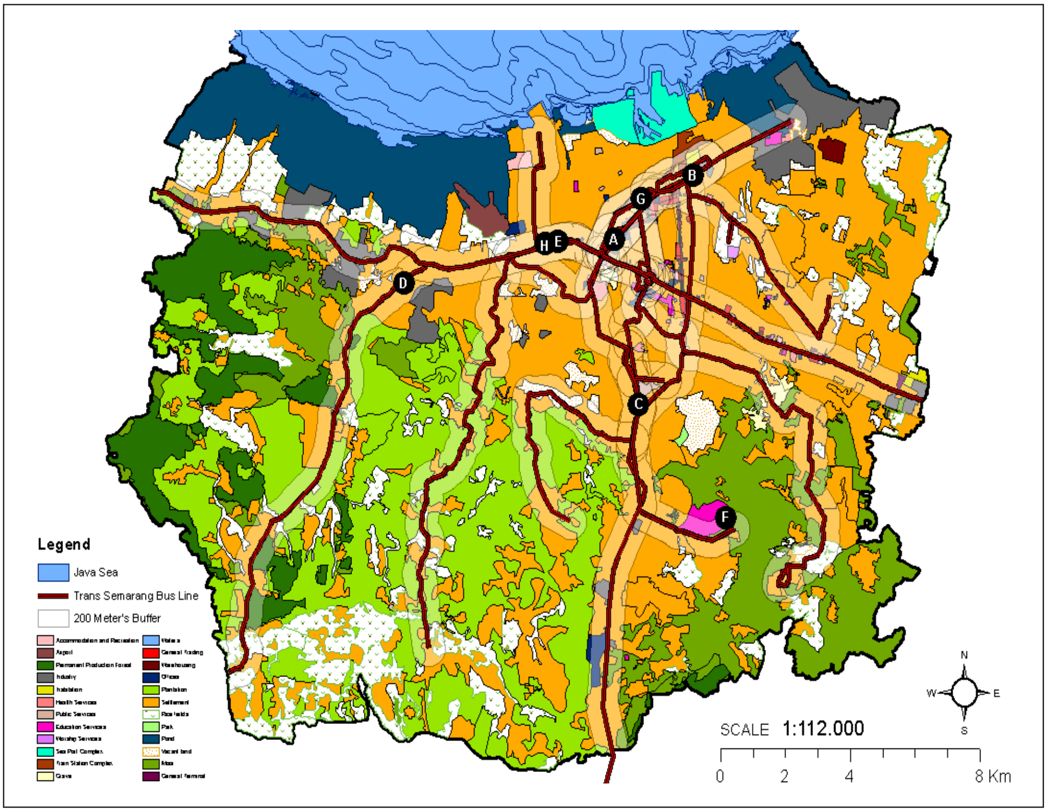

Figure 4.The distribution of land use and location of balancing index sample points in Semarang City

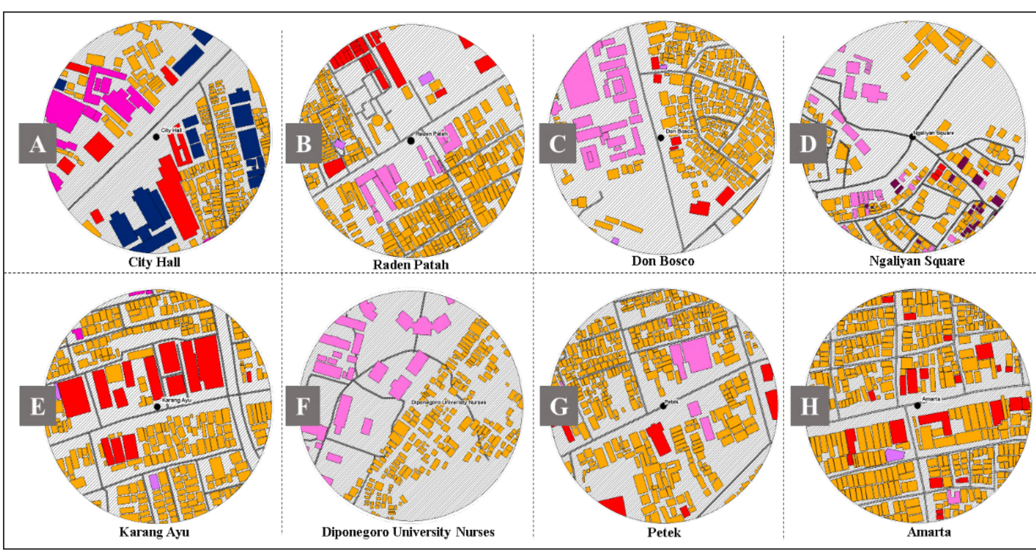

Figure 5. The land use corridor and highest balancing index value (200 meters) ; (A) Corridor II, (B) Corridor IIIA, (C) Corridor IIIB, (D) Corridor IV, (E) Corridor V, (F) Corridor VI, (G) Corridor VII, (H) Corridor I & VIII.

V area, is located at the Karang Ayu bus-stop, with a value of 1.00 (very balanced), and dominated by settlement land-use. Figure 5, section F shows the highest balancing index value in Corridor VI, is located at the Diponegoro University Nursing bus-stop (educational area), with a value of 1.04, and dominated by non-residential land-use, in the form of educational buildings. Meanwhile in Figure 5 section G, shows the the highest balancing index in Corridor VII is at the Petek bus-stop point, with a value of 0.99, and dominated by non-residential land use, in the form of trade as well as services.

The diversity analysis results for all Bus Trans Semarang corridors had the same pattern of balance index. In addition, locations with the highest balancing index, were dominated by land-use for education, trade, and services. Several studies stated commercial land-uses (educational with trade and services) were able to increase people's interest in walking activity, within the area (Miranda-Morenoa et al., 2011; Townsend & Zacharias, 2010; Chalermpong, 2007). Based on field observations, activities in the area of education, trade and services are conducted only at morning as well as evening, especially on weekdays (Monday-Friday), and pedestrian walkways are rarely used during holidays. In addition, an increase in attractions is required to bring in and improve activities, thus, allowing public facilities, including pedestrian walkway, to function optimally. According to Untermann and Lynn (1984), areas with mixed land-use characteristics on foot are more attractive, because the resulting movements are more diverse. Therefore, various types of land-use are required to improve population activities' pattern, consequently, optimizing the usage of space and creating a sustainable pedestrian walkways system.

Design Analysis

The pedestrian walkways design analysis showed Corridors IV, I, and II are routes with the highest number of inclines, crossings, and irregularities in comparison with the others as indicated in Table 4. Moreover, a linear pattern is produced towards the pedestrian walkway facilities when compared with the data presented in Table 1 and the corridors with the highest number of pedestrians were observed to have the tendency of having more complete facilities. It was also discovered that the closeness to the city center where there is a denser population activity level leads to a better and more complete walkway facilities design. Meanwhile, some locations observed to be far from the city center such as those traversed by Corridor VI have pedestrian walkways with a width of 1m-2m and are only equipped with vegetations as shown in Table 4 and Figure 6.

The sidewalks along the Bus Trans Semarang corridor needs improvement due to the differences observed between the current condition and user needs. The region's undulating topography and climatic conditions makes the average walking distance in Semarang City to be only 200m-250m. Therefore, the completeness of the design components and city environmental conditions for the pedestrian walkways has the ability to increase people's

Table 4
Complete pedestrian walkways design for the Bus Trans Semarang corridor radius 200 meters (Total)

Corridor	Pedestrian walkways Large (m)	Lanes of the road	Number of			Street Furniture
			Inter sections	Ramp	Crossings	
I*	1-5	2 – 6	172	267	42	Shade vegetation, bollards, lights, trash cans, traffic signs, seats, special lanes for the disabled.
II*	1-5	2	165	138	38	Traffic signs (no stopping sign, no parking), street lights, ways with disabilities, and potted vegetation.
IIIA	1-5	1 - 2	95	3	13	Lights, bollards, vegetation, traffic signs, trash cans, fire hydrants.
IIIB	1-1.5	1 - 2	246	0	22	Shade vegetation, and traffic signs.
IV*	1-3	2 - 4	110	396	30	Shade vegetation, bollards, lights, traffic signs, and special lanes for the disabled.
V	0.5-2.5	1 - 2	170	27	31	Shade vegetation, lights, traffic signs, benches, and special lanes for people with disabilities.
VI	1-3	2	132	40	18	Traffic lights and signs.
VII	1-2.5	1 - 2	127	21	12	Shade vegetation, lights, traffic signs, and ways for the disabled.
VIII	1-3	2 - 6	24	184	16	Shade vegetation, special lanes for people with disabilities, and traffic signs.

Note. corridor with the most complete design elements

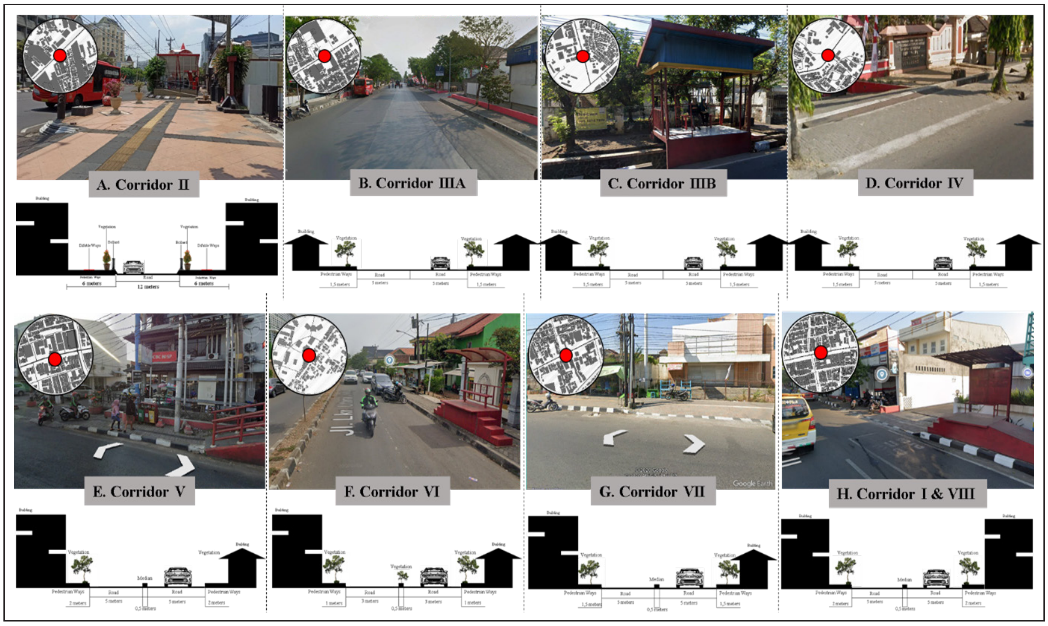

Figure 6. Pedestrian walkways conditions throughout the Bus Trans Semarang corridor. Sample of pedestrian walkways for corridor II, IIIA, IIIB, IV, V, VI, VII, and VIII.

willingness to walk to and from a destination (Özbil et al., 2015). It has also been reported that completed facilities such as ramps, sidewalks, vegetation, and several others affect walking activities in the area (Dixon, 1996; Munshi, 2016). However, the country has a tropical climate and year-round sunshine which causes some level of discomfort in engaging in outdoor activities such as walking. This means there is a need for adjustment based on the climate by using vegetation as shade which has been reported to be applicable in four-seasoned countries as observed in Montreal, Canada (Miranda-Morenoa et al., 2011). This vegetation also has the ability to produce sufficient oxygen and reduce carbon dioxide from motorized pollution at the same time. This, therefore, means it is necessary to have a pedestrian walkway with complete facilities and focus on both environmental and climatic conditions in order to achieve a sustainable transportation system.

The Built Environment Model Affecting Pedestrians

The linear regression test conducted using the partial coefficient T-test method was used to determine the significance of the relationship between two or more variables. This involves the application of two things which are the coefficient T and the significant results as the benchmarks. The number of pedestrian passengers at the Bus Trans Semarang per corridor (Y) was used as the dependent variable while the built environment which included the total density (X1), balancing index diversity (X2), and the number of walkway design elements (X3) in a radius of 200 from corridors were used as the independent variables. The results presented in Table 5 showed the T-value of density (X1) is 0.454 with a significance value of 0.669 (>0.05) and this means this variable did not significantly influence the pedestrian intensity (Y) due to the fact that the calculated T-value was lesser than the T-table value of 2.353 while the significance is greater than 0.05.

The table also shows diversity (X2) had a coefficient T-value of 7.028 (> 2.353) with a significance calculated value of 0.001 (<0.05) and this means there is a significant relationship between the pedestrian intensity (Y) and diversity (X2). This shows that

Table 5
The results of data processing linear regression (partial T-test) SPSS

Code	Independent Variable	Unstandardized B	T*	Sig**
Coefficient		2.630		
X1	Density (Floor Area Ratio calculation)	0.011	0.454	0.669
X2	Diversity (The ratio of residential and non-residential land or Balancing Index)	2.172	7.028	0.001
X3	Design (The completeness of the pedestrian walkway elements)	0.000	1.624	0.165

Note. The F table value is 2.35: *If T count> T the data table has a close relationship; **Sig <0.05 has a significant relationship meaning diversity has a positive influence on the intensity of pedestrians at the research location and this is reflected in the more balanced use of land in some areas which led to a higher frequency of people taking a walk. Moreover, design (X3) was found not to have a significant relationship with the pedestrian intensity (Y) as observed in the smaller calculated T-value of 1.624 in comparison with the 2.353 recorded on the T-table with the significance calculated also indicated to be greater than the standard of tolerance (> 0.05).

The linear regression model in Equation 6 showed the diversity variable had a positive effect on the frequency of pedestrians as indicated by the higher level of balancing index in an area which led to an increase in the number of pedestrians. However, when the probability of diversity or balancing index increased by 2.172, the frequency of pedestrians was observed to have risen by 2.630million in a year as indicated in Equation 6.

$$Y = 2.630 + 2.172 \text{ x } 2 \qquad [6]$$

These results are similar to the findings of the research conducted in the City of Montreal, Canada where land diversity was reported to be influencing the tendency of a person to walk around the transit center (Miranda-Morenoa et al., 2011). The land designed for trade and services with school buildings were found to have the highest pedestrian movements. Moreover, a study in Bangkok also showed commercial land tends to encourage people to walk around transit centers (Townsend & Zacharias, 2010; Chalermpong, 2007). The environmental conditions along the transit-based transportation routes in Bangkok City have been observed to have the closest characteristics to the area studied in this present research. This involved the relative spreading out of the building density and land-use from the city center to the suburbs as well as the non-optimal facilities provided for the pedestrian walkways. Meanwhile, the differences observed are focused on the research area coverage, topographical conditions, and urban development policies. For example, the density of Montreal and Beijing tends to influence people to walk frequently due to their flat topography, vertical development policies, and the relatively close distance between buildings and transit centers. The pedestrian design elements in Montreal are also relatively complete when compared to Semarang and Bangkok City of Thailand. The model produced from the analysis is, however, presented in the following Figure 7.

CONCLUSION

The analysis showed the diversity component is an important feature of the built environment which significantly influences how frequent people walk along the Bus Trans Semarang. This was indicated by a high balancing index between residential and non-residential land-uses with the commercial lands dominated by activities in the form of trade, education, and service areas. Furthermore, the high mixed use of land areas tends

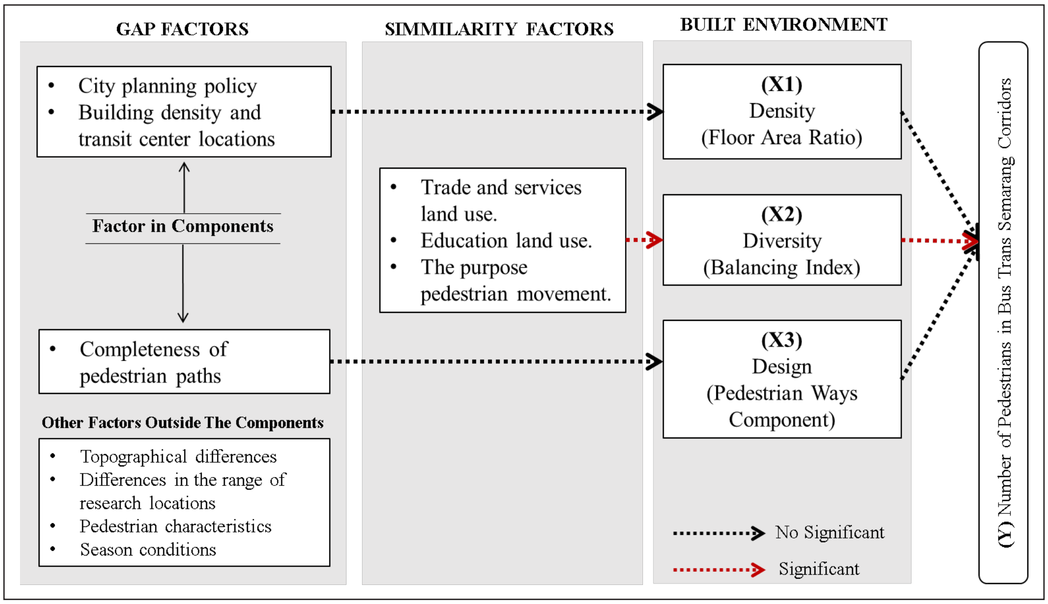

Figure 7. Model for the influence of built environment on pedestrian activity

to affect people's frequency to walk due to the diversity in their patterns of activity. The model also showed the existence of a positive relationship between the diversity variable and the frequency of pedestrians and this further indicates the ability of a higher level of balancing index to increase the frequency of pedestrians in the study area.

The two other components including density and design were, however, observed not to have any effect on how frequent people walk. Moreover, the distance between the buildings tends to be far apart due to the very minimal optimization of vertical development. The lack of pedestrian facilities along the Bus Trans Semarang corridor, especially in the city center area, is discovered to be part of the reasons the components did not have influence on the frequency to walk in the city of Semarang. There is also the fear to avoid the effect of this issue on people's desire to use transit-based transportation such as the Bus Trans Semarang. Therefore, a follow-up measure is expected to be made available to adjust pedestrians' demands to the built environment in order to create a sustainable transportation system.

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Dear Chief Executive Editor,
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We already made a revision of the manuscript with ID: JST-2293-2020, according to the input sent to us via email on March 26, 2021. Here's our response:

1. Figure 4 has been cited in the text on page 14 in the word document.
2. Figure 5 section G we have added in the text on page 15 in the word document.
3. We have removed two references because they were not used in the article, namely references Florez et al., (2014) and Rakhmatulloh et al., (2020).
4. Has included an English translation for reference SuaraMerdeka.com (2015). Page 24 in the word document.

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The Built Environment and its Impact on Transit based Transportation Users Walking Activity in Semarang, Indonesia

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ABSTRACT

The increase in mobility rate due to the current rise in population has become a challenge in urban development. This led to the development of pedestrian walkways, which are integrated with transit-based transportation, to minimize problems due to the high level of mobility of the urban population. According to some experts, environmental conditions are one of the main factors capable of affecting pedestrians' frequency. Therefore, this study explores the effect of the built environment, such as density, diversity, and design, on the pedestrian frequency of the Bus Trans Semarang passengers. Data were collected from 9 corridors, consisting of 447 bus stops, directly connected to the pedestrian walkways, as one of the feeders for transit-based transportation facilities. The analysis method used for each variable was the formulation technique, with data simulated using various applications, such as ArcGIS. The linear regression partial t-test model was also analyzed using SPSS, with the effect of pedestrian frequency on dependent variables determined, using the built environment elements (independent variable). The results showed a positive significance between the diversity variable and pedestrians' frequency along the Bus Trans Semarang corridors. Furthermore, the land that varies with the dominance of commercial and educational area has the highest attraction features that affects a person's frequency to walk.

Keywords: Built environment, pedestrian walkways, transit-based transportation

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INTRODUCTION

The development of a transit-based transportation system is intensively carried out as an alternative means of private transportation to overcoming population growth in various countries. According to Makarova et al. (2017), the Asian region is generally known for its unhealthy transportation system, which causes various problems, such as congestion, air pollution, and sprawl-related issues (Makarova et al., 2017). Therefore, to overcome this, the World Health Organization (WHO) encourages countries to implement sustainable transportation systems that focus on safe, efficient, accessible, affordable, inclusive, green, and healthy transportational mobility.

A Transit-Oriented Development (TOD) is a form of sustainable transportation that emphasizes integrating urban spatial design to unite people, activities, buildings, and public spaces through connectivity, accessible by walking (ITDP, 2017). Increasing walking intensity (walkability) is considered part of the effective solutions in overcoming unhealthy transportation because it minimizes congestion, increases environmental sustainability, encourages physical activity, improves public health, and enhances urban settlements' appropriateness (Blanco & Alberti, 2009). The pedestrian walkways, commonly referred to as a sidewalk in a transit-based transportation system, is a facility feeder that connects a transit centre with other activity functions (Hu et al., 2013). However, the lack of optimal pedestrian walkways is a challenge for establishing a sustainable transportation system in several countries.

Various studies suggested that the optimization of pedestrian walkways, such as the completeness of design components, an attractive, safe, and comfortable city shape increases residents' tendency to walk to a destination (Özbil et al., 2015). Furthermore, the developments of a land-use planning, and urban design are crucial in increasing pedestrian activity in cities (Timmermans, 2009). However, research on the relationship between the conditions of the built environment, and walking tendency in the transit-based transportation system is rare. Various parties have been inclined to focus on increasing the transportation system's capacity, without observing how the developments affect the environment. Therefore, the development of a new transportation system is linear with the uneven distribution of building density and land-use management, thereby leading to inadequate functioning of several pedestrian walkways.

The built-environment is a transit-based transportation system commonly found in European countries. The initial milestone associated with this technique was first carried out by Cervero & Kockelman (1997) in the European countries to welcome new urbanism concepts. According to them, the built environment means physical features of the urban landscape (i.e., alterations to the natural landscape). These authors formulate three main components to assess the built environment from the same source, namely density, diversity, and design.

The density is defined as the component produced by observing population frequency per household and building quality per area (Cervero & Kockelman, 1997; Monteiro & Campos, 2012; Zhang et al., 2016). Furthermore, this research and the pedestrian activity in previous studies observed that the areas with a high-density level are associated with walking (Oktaviani et al., 2020). A study carried out by Duduta (2013) developed indicators for assessing density components in constructing measurements, which are properly related to building height or the Floor Area Ratio (FAR) analysis method. The study takes a minimum distance of 200m from the stop point, which was recorded, and divided into three categories of level assessment, namely low (1-2 floors), medium (3-8 floors), and high (>8 floors) densities.

The diversity component is represented as a land-use balancing index used to compare the ratio of residential and non-residential (commercial) areas. According to Sung et al. (2013), the level of balancing land-use in an area rises, the activities of pedestrians relatively increased. Furthermore, by simplifying Cervero and Kockelman (1997) research, the diversity component emphasizes the calculation model of residential and non-residential land area ratios, which in this case, is measured by the balancing index formula (Sung et al., 2013). The diversity variable analysis results show the patterns of land use and its changes due to population mobility. Several studies, such as those carried out by Cervero, found that the effects of diversity have long been ignored.

The design component is part of the features referring to the assessment of pedestrian walkways and its integration with the road network system (Dixon, 1996; Munshi, 2016). Similar to diversity, the effects of design also have long been ignored in built environment analysis. However, the design component's measurement is more complicated than density and diversity, with a system of assessing pedestrian walkway completeness elements adjusted to environmental conditions (Zhang et al., 2016). Therefore, this study summarized the design indicators needed to identify the appropriate pedestrian walkways at the research location. This includes the lane width, route count, road intersection number, the presence of ramps, bridges, zebra crossings, and the completeness of street furniture.

The country context plays an essential role in ascertaining the built environment assessment of pedestrian activities. The biggest question that emerged from previous research is whether the context of the European region's built environment is similar to the Asian zone. Furthermore, a research in downtown Montreal, Canada showed that the components of the built environment, density (population, number of jobs, schools, and bus stops), diversity (commercial land use), and design (percentage of main arteries, average length of roads), affected pedestrian activity (Miranda-Morenoa et al., 2011). This city's position in Canada is a provincial capital not included in the national central area. It is observed to be a part of the cities located in developed countries. In this location, the problem encountered was a lack of pedestrians' security on the walkways. However, this location had a complete pedestrian walkways element, surrounding skyscrapers. As a four-season country, the provision of vegetation along the pedestrian walkways in the city is designed to suit seasonal conditions. This is because the designs that adapt to climate change and periods are being intensified to create sustainable urban life.

The discussion of the built environment, on pedestrian walkways in developing countries, for example, the transit area in Bangkok, Thailand, was developed from an interplay between people's tendency to walk and the diversity of land-use around the transit area (Townsend & Zacharias, 2010). The walkways condition in Bangkok, Thailand, is associated with air pollution and lack of sidewalks (Townsend & Zacharias, 2010; Chalermpong, 2007). Therefore, from this study, it is obtained that the development of commercial, retail, and residential land is relatively high around the transit centre, which shows that the influence of diversity is high on pedestrian movement patterns.

The research carried out in other Asian regions, such as Beijing, China, obtained different results. According to Zhao et al. (2018), the findings on the built environment at the environmental-scale transit centres in Beijing, show that the density component plays a substantial role in influencing pedestrian activities. The study showed that the pedestrian walkway components in Indonesia was complete compared to those in Bangkok. Also, the influence of the vertical building construction policy in the central area of Beijing City is the basis for forming a compact area, with relatively close distances between buildings. Based on that statement, the density of the built environment in this area influences a person's inclination to walk. Therefore, the geographic characteristics with the research's scope carried out in Bangkok and Beijing relatively similar. This is because they are often conducted in locations with relatively flat homogeneous topography, using city-scale research coverage.

Semarang is one of the major cities in Indonesia, located in Central Java Province. The city intensively plans to develop a Transit Oriented Development (TOD) system, accommodate the community's mobility needs, and create a sustainable transportation channel. The requirement needed for the development of the TOD system in this city is the Bus Trans Semarang. The relationship between the built environment and pedestrian activities in the central transit area, along the Bus Trans Semarang corridor, seems interesting because it covers the city centre area with a diverse topography in its surroundings. The problem of pedestrian walkways provision in Semarang City is the same as that of Bangkok, which is associated with pollution related-issues, and lack of sidewalks. Based on further data, it was observed that approximately 88% of Bus Trans Semarang passengers walked to or from the bus stops (Purwanto & Manullang, 2018). This result is certainly in contrast to the lack of pedestrian walkways provision in the city of Semarang, which then causes a gap between availability and demand.

Policies regarding land-use, regulated by City Territory Section (CTS), indicated that Semarang City's use is very diverse. Furthermore, the absence of a firm policy on building construction efforts has led to a high sprawl level in this area. Therefore, this study aims to ascertain the best-built environment model, which affects a person's tendency to walk along the Bus Trans Semarang corridor, from the city centre to the suburbs. It also complements previous research that only focused on density conditions in the built environment analysis. This research is further accompanied with a question, such as, ‘Do the built environment components affect the pedestrian activity of transit-based transportation users in Semarang City?’

METHODS

Semarang Study Area

Semarang City is one of the metropolitan cities in Indonesia, located in Central Java Province, with a population of 1.79 million people. According to the data obtained from the Semarang City Statistics Centre in 2019, the population of this area keeps increasing by 50% yearly, accompanied by the provision of a non-optimal public transportation system. This location is one of the pilot project for Bus Rapid Transit (BRT) development in Indonesia, with the provision of Bus Trans Semarang in 2009, to help improve the quality of transportation system (SuaraMerdeka, 2015).

Therefore, this research covers all Bus Trans Semarang routes, consisting of, Corridors I, II, IIIA, IIIB, IV, V, VI, VII, and VIII, as shown in Figure 1. According to Kim et al. (2018), two methods are used to measure the built environment, based on the area's scope, namely, the street level of 50m and the neighborhood position at a maximum radius of 400m, from the observation point. The data showed that the maximum distance for walking in Semarang City was only 200m-250m between destination locations (Purwanto & Manullang, 2018). Therefore, sampling of the observation area, using the neighbourhood level method, with a radius of 200m from the right and left of the road was carried out in this research.

In this study, the entire Bus Trans Semarang corridor has 596 bus-stops, scattered from the city centre to the suburbs, while also connecting various important land-uses, such as terminals, government areas, education fields, and many more, as shown in Table 1. Data from the Semarang City Transportation Office in 2018 showed a significant increase in Bus Trans Semarang passengers from 2010-2018. The total number of passengers between 2010 and 2018 were 369,326 and 10,210,296, respectively. Furthermore, the largest contributor for pedestrians in this study was Corridor I, which had massive bus-stops and fleets compared to the other eight corridors. Based on the data collected from the field observations, pedestrian activities along the Bus Trans Semarang corridor were dominated by school, work, and recreational activities. City centre areas such as Corridors I, II, and IV, had more massive pedestrian activities than other zones.

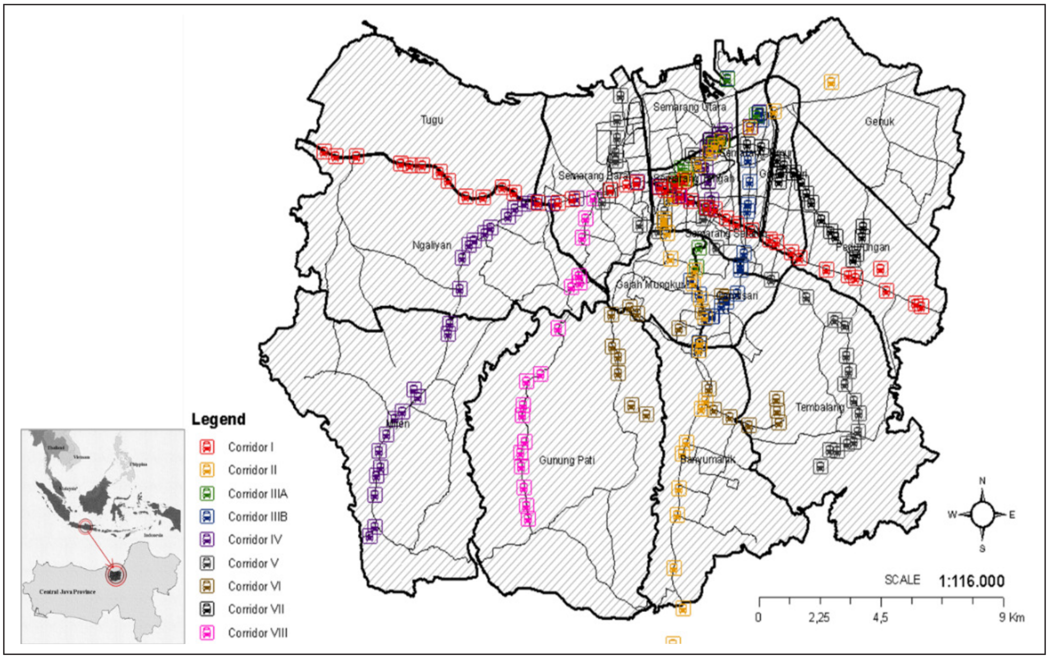

Figure 1. Bus Trans Semarang stops in the study area

Table 1
Bus Trans Semarang corridor profile

Corridor	Rute	Number of			Corridor Length (Km)	Operating Years
		Pedestrian (People)	Bus (Unit)	Stops (Unit)		
I*	Mangkang Terminal→Penggaron Terminal.	2,713,852	25	81	60.0	2009
II	Terboyo Terminal→Sisemut Terminal.	838,081	34	74	26.5	2012
IIIA	Tanjung Emas Port→KagokTanjung Emas Port.	166,934	16	45	10.5	2014
IIIB	Tanjung Emas Port→Elizabeth Hospital→Tanjung Emas Port.	111,289		40	10.0	2014
IV	Cangkiran Terminal →Semarang Tawang Station.	520,436	22	87	22.3	2013
V	Meteseh Residential AreaAirport→Marina Beach.	366,319	16	75	25.9	2017
VI	Diponegoro University→Semarang State University.	257,831	16	63	13.4	2017
VII	Terboyo Terminal→Semarang City Hall.	87,886	13	63	6.9	2018
VIII	Cangkiran Terminal→Simpang Lima (City Center).	56,799	20	68	22.4	2019

Note. *corridors with the most pedestrians

Quantitative Analysis

This research utilized the quantitative research technique, which focused on analyzing the built environment in the form of density, diversity, and design. Data was collected through naturalistic direct field observation methods. Furthermore, the density analysis assessed the population frequency by comparing the total populace, using the interpolation method (ArcGIS 10.3). This analysis produced a spatial picture of population density in each Corridor. Also, the density component analysis used the numerical calculation method, such as the Floor Area Ratio (FAR), to compare the number of buildings per floor area. The calculations in accordance with Duduta's (2013) research, were divided into three categories, namely low (Equation 1), medium (Equation 2), and high (Equation 3) densities, as shown in Equation 1-3.

$$\text{Low density} = \frac{\text{number of buildings } 1-2 \text{ floors}}{\text{the total number of buildings within a 200 meter radius of the stop point}} \quad [1]$$

$$\text{Medium density} = \frac{\text{number of buildings } 3-8 \text{ floors}}{\text{the total number of buildings within a 200 meter radius of the stop point}} \quad [2]$$

$$\text{High density} = \frac{\text{number of buildings } >8 \text{ floors}}{\text{the total number of buildings within a 200 meter radius of the stop point}} \quad [3]$$

Diversity components were analyzed, using the land-use ratio analysis, while comparing the residential, commercial, office space, public services, and recreational areas, to the total space around the Bus Trans Semarang bus-stop, in each Corridor. According to Sung et al. (2013), this diversity of land-use is used to compare the residential and non-residential areas, using the balancing index (RNR) formula, as shown in Equation 4.

$$RNRi = 1 - \left[\frac{\text{Res} - \text{Non res}}{\text{Res} + \text{Non res}}\right] \rightarrow \text{The closer to 1, the more balance} \quad [4]$$

The design component was carried out by analyzing the road structure and pedestrian walkways' completeness features, based on movement needs. In this case, the assessment indicators were completeness elements, which include crossings, ramps, intersections, lane width, number of routes, and sidewalk furniture. The analysis of this component was presented to visualize the existing conditions, which were compared with the required pedestrian feature demand data, in Semarang. Further, the overall results of the density, diversity, and design analysis were processed, using the significance of linear regression (partial T-test) and the SPSS Statistics 24 application, to determine the effect of the built environment on walking activities in each Corridor. The model formula used in determining the influence between the variables is shown in Equation 5.

$$Y = a + b(X) \quad [5]$$

Where;
Y = frequency of pedestrians (person)
a = constant
b = coefficient
X = built environment variables

Linear regression had been widely used in previous studies to produce a relationship model between the built environment variables and pedestrian movement patterns in an area. The requirements of linear regression analysis (partial T-test) is that when the results of the coefficients (t) are greater than the t-table (2.35), with the regression data's significant value less than 0.05 (<0.05), then both variables (dependent & independent), influences each other. The built environment variable consists of density (X1), diversity (X2), and design (X3) as independent variables, which correlates with the pedestrian intensity in each Corridor (Y), as shown in Figure 2.

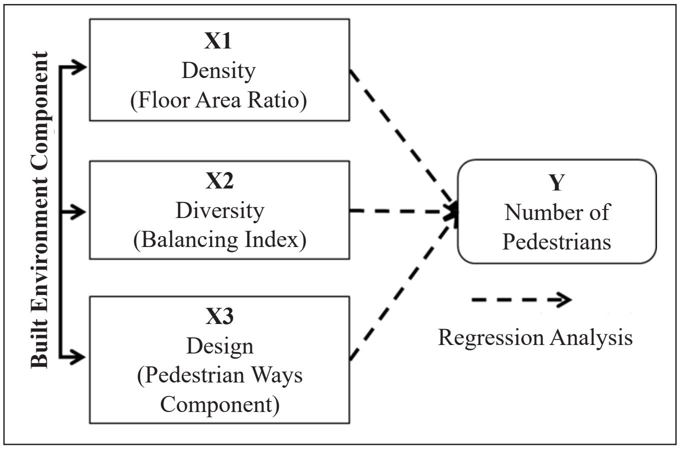

Figure 2. Linear regression analysis diagram

RESULT AND DISCUSSION

Density Analysis

Based on the comparative calculation between total population and land area in Semarang City, the highest population density was observed to occur in the downtown vicinity (Figure 3). This is similar to the theory of urban growth in the world, stating "the closer to the city centre, the higher the population density" (Fee & Hartley, 2011). The high population density increases the demand for public transportation, including BRT, therefore, confirming the need to integrate services in areas with high density (Patankar et al., 2007). Figure 3

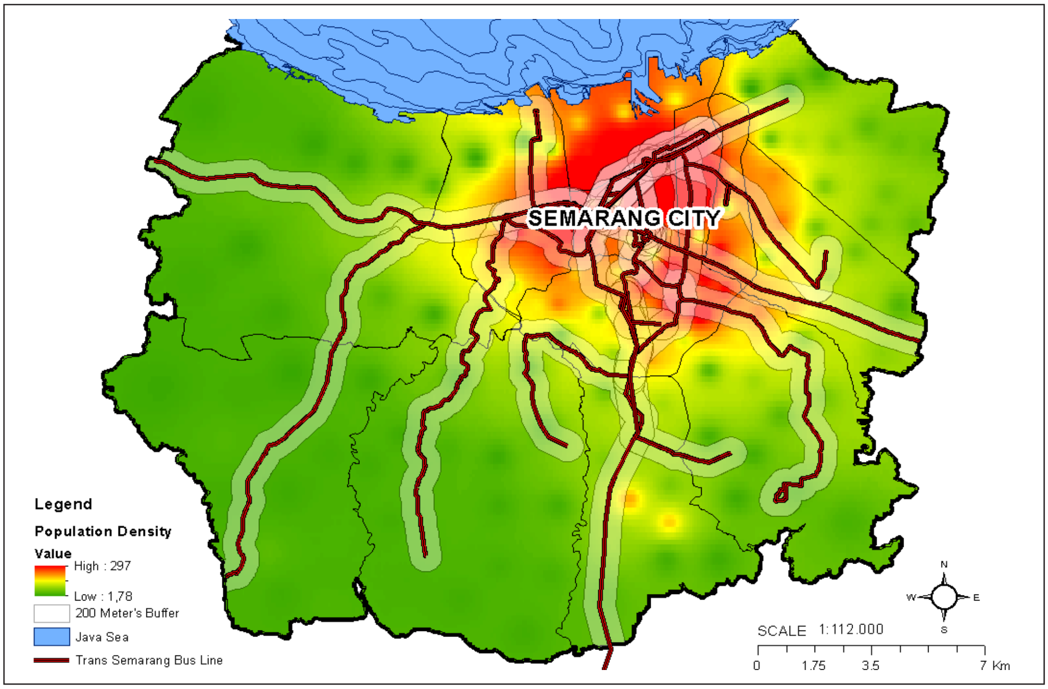

Figure 3: The population density in buffer area, 200 meters from bus corridor

shows the implementation of the Bus Trans Semarang system has paid attention to this theory, as observed in all routes (I-VIII) passing through the city centre and numerous bus-stops provided.

In addition to calculating population density, the component was measured by observing the quality of building. Table 2 shows the calculation of density values, with IIIB having the highest total, compared to other routes. The density in this corridor was dominated by 1-2 floor buildings, indicated by the low frequency of 0.983. Meanwhile, data from the observations showed the entire Bus Trans Semarang corridor were dominated by developments in a horizontal direction and following the road network. According to Table 2, with regard to the element density conditions for each corridor, only three out of nine routes had a relatively high frequency value (33%).

Furthermore, the research on transportation hubs in Japan discovered a high Floor Area Ratio (FAR) with optimized vertical building construction, improves land-use quality, while creating effective movement for pedestrians (Yang & Yao, 2019). Thus, high density areas surrounded by vertical buildings, minimized the use of motorized vehicle and increased pedestrian intensity (Cervero & Kockelman, 1997; Monteiro & Campos, 2012; Zhang et al., 2016). Also, the density analysis along the Bus Trans Semarang corridor, produced results contrary to the study by Zhao et al. (2018), stating the dominance of density effect on the built environment and pedestrian activity in Beijing was high. This was in line with

Table 2
The condition of the element density of all corridor radius 200 meters (Total)

Corridor	Building				Lenght of corridor (Km)	Large of corridor (Ha)	Total Density (unit/ Ha)	Density		
	1-2 floors (unit)	3-8 floors (unit)	>8 floors (unit)	Total (unit)				Low	Medium	High
(1)	(2)	(3)	(4)	(5)	(6)	200*(6) = (7)	(5)/(7)	(2)/(5)	(3)/(5)	(4)/(5)
I	4,358	290	8	4,656	60.0	1,200	4	0.897	0.096	0.007
II	3,833	130	3	3,966	26.5	530	7	0.960	0.043	0.001
IIIA	3,258	84	6	3,348	10.5	210	16	0.958	0.039	0.003
IIIB*	6,249	85	6	6,340	10.0	200	32	0.983	0.016	0.001
IV	714	167	21	902	22.3	446	2	0.758	0.172	0.028
V	968	152	18	1,138	25.9	518	2	0.817	0.164	0.039
VI	3,587	121	0	3,708	13.4	268	14	0.936	0.064	0.000
VII	654	110	2	766	6.9	138	6	0.824	0.149	0.002
VIII	171	96	7	274	22.4	448	1	0.632	0.341	0.027

Note. *corridor with the highest density

the Chinese government's regulation of intensifying vertical development, to implement a sustainable city development, and is different from the existing regulation condition in Semarang, with no emphasis on vertical building. However, increased vertical building growth is required, especially in downtown areas, in terms of land-use optimization, with the creation of a pedestrian-friendly and sustainable transit-based transportation system.

Diversity Analysis

Table 3 shows the equilibrium calculation results, with the total balance index of all the corridors close to 1, thus, categorized as areas with mixed land-use, possessing high parameters (Sung et al., 2013). Furthermore, the highest balancing index of 1.110, was obtained in the Corridor II area, with trade and service centre as the mainland-use. The area's function as a centre for trade and services, has led to increasingly diverse land-use, and the proportion of residential (60 hectares) to non-residential (59 hectares) land in the area is very stable within a 200m radius, from the transit centre. As one of the longest routes, Corridor I had the smallest balancing index of 0.395 (getting away from 1). In this corridor, the proportion of residential to non-residential land-use area is unbalanced. The residential land amounts to 98.70ha, while non-residential areas dominated by trade and services, offices, and industry, was only 40.22ha.

In addition to the total calculation results, the table above also explains the stop points with the highest balancing index value on each route. This aims to serve as the main sample, showing the spatial balancing index conditions through land use, per building. In general, Figure 4 explains the position of the balancing index sample point for each

Table 3
Condition element diversity for all corridor radius 200 meters (Total)

Corridor	Res (Ha)	Non-res (Ha)	Balancing Index	Landuse
	(1)	(2)	(1)/(2) = (3)	(4)
I**	98.70	40.22	0.395	Settlements, industry, trade and services, warehousing, worship, defense and security, offices, education, health, recreation, public spaces, sports.
II*	60.59	58.72	1.110	Offices, trade and services, police education and sports, industry, and housing.
IIIA	64.58	89.44	0.831	Defense and security, education, health, offices, public spaces, recreation, settlements, trade and services, and worship.
IIIB	56.55	23.04	1.184	
IV	261.32	339.46	0.870	Offices, worship, health, trade and services, education, housing, recreation, defense and security, and transportation.
V	215.86	311.21	0.820	Education, health, industry, offices, defense and security, housing, sports, recreation, trade and services, and worship.
VI	57.68	31.10	1.314	Defense and security, education, health, offices, settlements, recreation, trade and services, and worship.
VII	129.01	247.47	0.685	Education, health, industry, offices, defense and security, housing, sports, recreation, trade and services, and worship.
VIII	158.80	167.19	0.938	Trade and services, worship, health, education, offices, recreation, defense and security, and settlements.

Note. Res (Rsidential area), Non-res (Non-residential area): *corridor with the highest balancing index; **corridor with the lowest balancing index

corridor on the distribution of land use in Semarang City. Meanwhile, Figure 5, section H shows the location of the highest balancing index for Corridor I is the same with VIII, at the Amarta bus-stop point, with a value of 1.10, and dominated by non-residential land-use, including trade and services. Meanwhile, Figure 5, section A show the location with the highest balancing index for Corridor II area is the City Hall bus-stop, with a value of 0.96, and dominated by non-residential land-use, in the form of offices as well as educational buildings. Figure 5, section B shows the location with the highest balancing index on Corridor IIIA is the Raden Patah bus-stop point, with a value of 1.06, and dominated by non-residential land-use in the form of trade as well as services, with school buildings. However, Figure 5, section C shows the highest balancing index for Corridor IIIB was located at the Don Bosco stopping point, with a value of 1.06, and dominated by residential land use, including housing and school buildings.

Furthermore, Figure 5, section D shows the location with the highest balancing index in the Corridor IV area is Nyaliyan Square bus-stop, with a value of 0.99, and dominated by non-residential land use, in the form of trade as well as services, with educational buildings. Meanwhile, Figure 5, section E shows the highest balancing index in Corridor

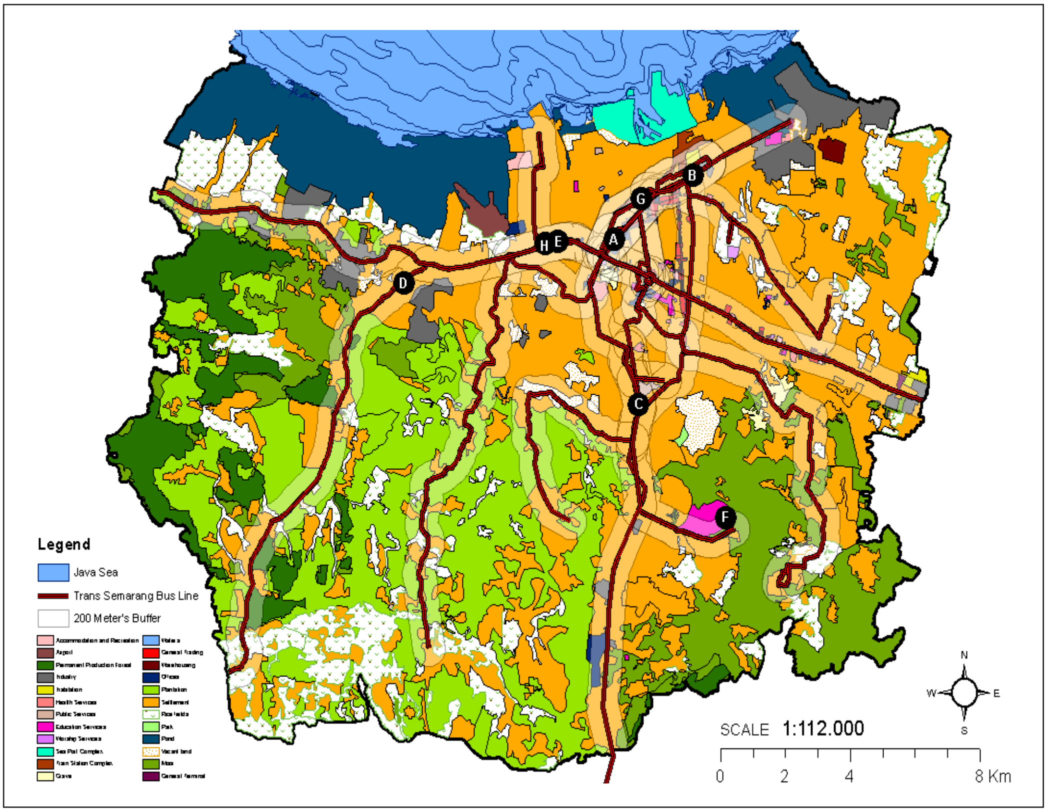

Figure 4.The distribution of land use and location of balancing index sample points in Semarang City

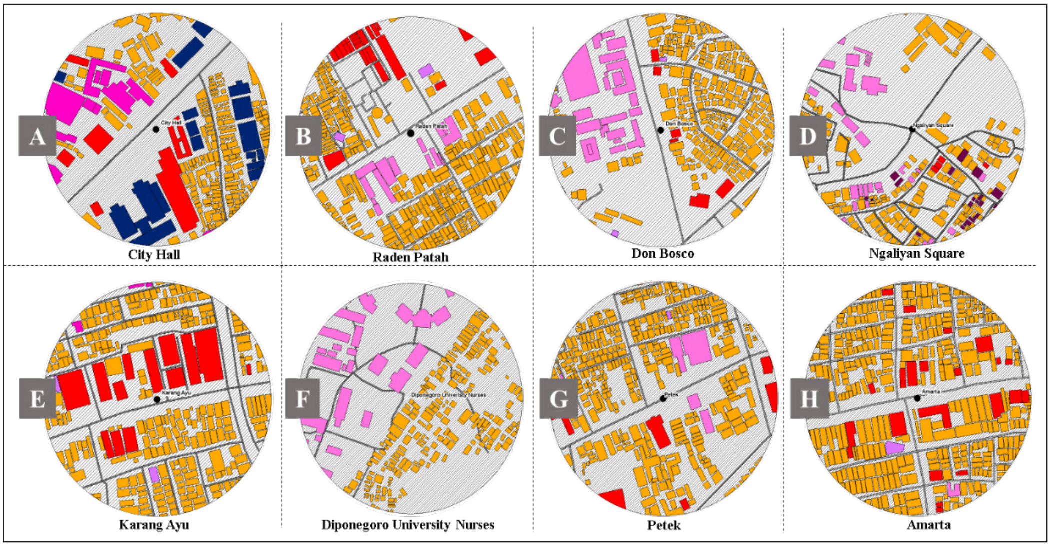

Figure 5. The land use corridor and highest balancing index value (200 meters) ; (A) Corridor II, (B) Corridor IIIA, (C) Corridor IIIB, (D) Corridor IV, (E) Corridor V, (F) Corridor VI, (G) Corridor VII, (H) Corridor I & VIII.

V area, is located at the Karang Ayu bus-stop, with a value of 1.00 (very balanced), and dominated by settlement land-use. Figure 5, section F shows the highest balancing index value in Corridor VI, is located at the Diponegoro University Nursing bus-stop (educational area), with a value of 1.04, and dominated by non-residential land-use, in the form of educational buildings. Meanwhile in Figure 5 section G, shows the the highest balancing index in Corridor VII is at the Petek bus-stop point, with a value of 0.99, and dominated by non-residential land use, in the form of trade as well as services.

The diversity analysis results for all Bus Trans Semarang corridors had the same pattern of balance index. In addition, locations with the highest balancing index, were dominated by land-use for education, trade, and services. Several studies stated commercial land-uses (educational with trade and services) were able to increase people's interest in walking activity, within the area (Miranda-Morenoa et al., 2011; Townsend & Zacharias, 2010; Chalermpong, 2007). Based on field observations, activities in the area of education, trade and services are conducted only at morning as well as evening, especially on weekdays (Monday-Friday), and pedestrian walkways are rarely used during holidays. In addition, an increase in attractions is required to bring in and improve activities, thus, allowing public facilities, including pedestrian walkway, to function optimally. According to Untermann and Lynn (1984), areas with mixed land-use characteristics on foot are more attractive, because the resulting movements are more diverse. Therefore, various types of land-use are required to improve population activities' pattern, consequently, optimizing the usage of space and creating a sustainable pedestrian walkways system.

Design Analysis

The pedestrian walkways design analysis showed Corridors IV, I, and II are routes with the highest number of inclines, crossings, and irregularities in comparison with the others as indicated in Table 4. Moreover, a linear pattern is produced towards the pedestrian walkway facilities when compared with the data presented in Table 1 and the corridors with the highest number of pedestrians were observed to have the tendency of having more complete facilities. It was also discovered that the closeness to the city center where there is a denser population activity level leads to a better and more complete walkway facilities design. Meanwhile, some locations observed to be far from the city center such as those traversed by Corridor VI have pedestrian walkways with a width of 1m-2m and are only equipped with vegetations as shown in Table 4 and Figure 6.

The sidewalks along the Bus Trans Semarang corridor needs improvement due to the differences observed between the current condition and user needs. The region's undulating topography and climatic conditions makes the average walking distance in Semarang City to be only 200m-250m. Therefore, the completeness of the design components and city environmental conditions for the pedestrian walkways has the ability to increase people's

Table 4
Complete pedestrian walkways design for the Bus Trans Semarang corridor radius 200 meters (Total)

Corridor	Pedestrian walkways Large (m)	Lanes of the road	Number of			Street Furniture
			Inter sections	Ramp	Crossings	
I*	1-5	2 – 6	172	267	42	Shade vegetation, bollards, lights, trash cans, traffic signs, seats, special lanes for the disabled.
II*	1-5	2	165	138	38	Traffic signs (no stopping sign, no parking), street lights, ways with disabilities, and potted vegetation.
IIIA	1-5	1 - 2	95	3	13	Lights, bollards, vegetation, traffic signs, trash cans, fire hydrants.
IIIB	1-1.5	1 - 2	246	0	22	Shade vegetation, and traffic signs.
IV*	1-3	2 - 4	110	396	30	Shade vegetation, bollards, lights, traffic signs, and special lanes for the disabled.
V	0.5-2.5	1 - 2	170	27	31	Shade vegetation, lights, traffic signs, benches, and special lanes for people with disabilities.
VI	1-3	2	132	40	18	Traffic lights and signs.
VII	1-2.5	1 - 2	127	21	12	Shade vegetation, lights, traffic signs, and ways for the disabled.
VIII	1-3	2 - 6	24	184	16	Shade vegetation, special lanes for people with disabilities, and traffic signs.

Note. corridor with the most complete design elements

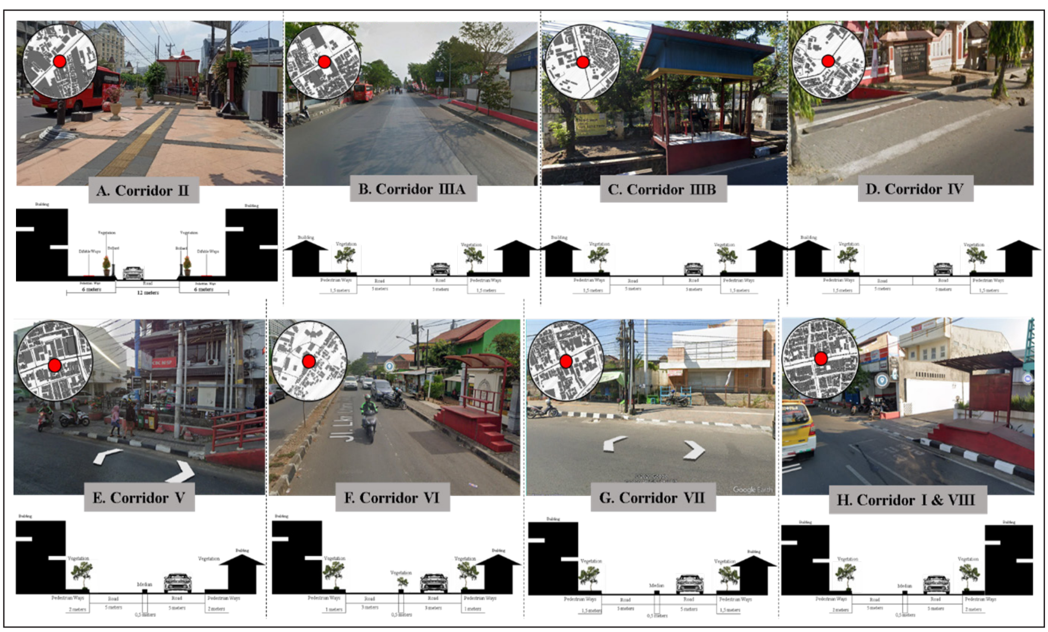

Figure 6. Pedestrian walkways conditions throughout the Bus Trans Semarang corridor. Sample of pedestrian walkways for corridor II, IIIA, IIIB, IV, V, VI, VII, and VIII.

willingness to walk to and from a destination (Özbil et al., 2015). It has also been reported that completed facilities such as ramps, sidewalks, vegetation, and several others affect walking activities in the area (Dixon, 1996; Munshi, 2016). However, the country has a tropical climate and year-round sunshine which causes some level of discomfort in engaging in outdoor activities such as walking. This means there is a need for adjustment based on the climate by using vegetation as shade which has been reported to be applicable in four-seasoned countries as observed in Montreal, Canada (Miranda-Morenoa et al., 2011). This vegetation also has the ability to produce sufficient oxygen and reduce carbon dioxide from motorized pollution at the same time. This, therefore, means it is necessary to have a pedestrian walkway with complete facilities and focus on both environmental and climatic conditions in order to achieve a sustainable transportation system.

The Built Environment Model Affecting Pedestrians

The linear regression test conducted using the partial coefficient T-test method was used to determine the significance of the relationship between two or more variables. This involves the application of two things which are the coefficient T and the significant results as the benchmarks. The number of pedestrian passengers at the Bus Trans Semarang per corridor (Y) was used as the dependent variable while the built environment which included the total density (X1), balancing index diversity (X2), and the number of walkway design elements (X3) in a radius of 200 from corridors were used as the independent variables. The results presented in Table 5 showed the T-value of density (X1) is 0.454 with a significance value of 0.669 (>0.05) and this means this variable did not significantly influence the pedestrian intensity (Y) due to the fact that the calculated T-value was lesser than the T-table value of 2.353 while the significance is greater than 0.05.

The table also shows diversity (X2) had a coefficient T-value of 7.028 (> 2.353) with a significance calculated value of 0.001 (<0.05) and this means there is a significant relationship between the pedestrian intensity (Y) and diversity (X2). This shows that

Table 5
The results of data processing linear regression (partial T-test) SPSS

Code	Independent Variable	Unstandardized B	T*	Sig**
Coefficient		2.630		
X1	Density (Floor Area Ratio calculation)	0.011	0.454	0.669
X2	Diversity (The ratio of residential and non-residential land or Balancing Index)	2.172	7.028	0.001
X3	Design (The completeness of the pedestrian walkway elements)	0.000	1.624	0.165

Note. The F table value is 2.35: *If T count> T the data table has a close relationship; **Sig <0.05 has a significant relationship meaning diversity has a positive influence on the intensity of pedestrians at the research location and this is reflected in the more balanced use of land in some areas which led to a higher frequency of people taking a walk. Moreover, design (X3) was found not to have a significant relationship with the pedestrian intensity (Y) as observed in the smaller calculated T-value of 1.624 in comparison with the 2.353 recorded on the T-table with the significance calculated also indicated to be greater than the standard of tolerance (> 0.05).

The linear regression model in Equation 6 showed the diversity variable had a positive effect on the frequency of pedestrians as indicated by the higher level of balancing index in an area which led to an increase in the number of pedestrians. However, when the probability of diversity or balancing index increased by 2.172, the frequency of pedestrians was observed to have risen by 2.630million in a year as indicated in Equation 6.

$$Y = 2.630 + 2.172 \text{ x } 2 \quad [6]$$

These results are similar to the findings of the research conducted in the City of Montreal, Canada where land diversity was reported to be influencing the tendency of a person to walk around the transit center (Miranda-Morenoa et al., 2011). The land designed for trade and services with school buildings were found to have the highest pedestrian movements. Moreover, a study in Bangkok also showed commercial land tends to encourage people to walk around transit centers (Townsend & Zacharias, 2010; Chalermpong, 2007). The environmental conditions along the transit-based transportation routes in Bangkok City have been observed to have the closest characteristics to the area studied in this present research. This involved the relative spreading out of the building density and land-use from the city center to the suburbs as well as the non-optimal facilities provided for the pedestrian walkways. Meanwhile, the differences observed are focused on the research area coverage, topographical conditions, and urban development policies. For example, the density of Montreal and Beijing tends to influence people to walk frequently due to their flat topography, vertical development policies, and the relatively close distance between buildings and transit centers. The pedestrian design elements in Montreal are also relatively complete when compared to Semarang and Bangkok City of Thailand. The model produced from the analysis is, however, presented in the following Figure 7.

CONCLUSION

The analysis showed the diversity component is an important feature of the built environment which significantly influences how frequent people walk along the Bus Trans Semarang. This was indicated by a high balancing index between residential and non-residential land-uses with the commercial lands dominated by activities in the form of trade, education, and service areas. Furthermore, the high mixed use of land areas tends

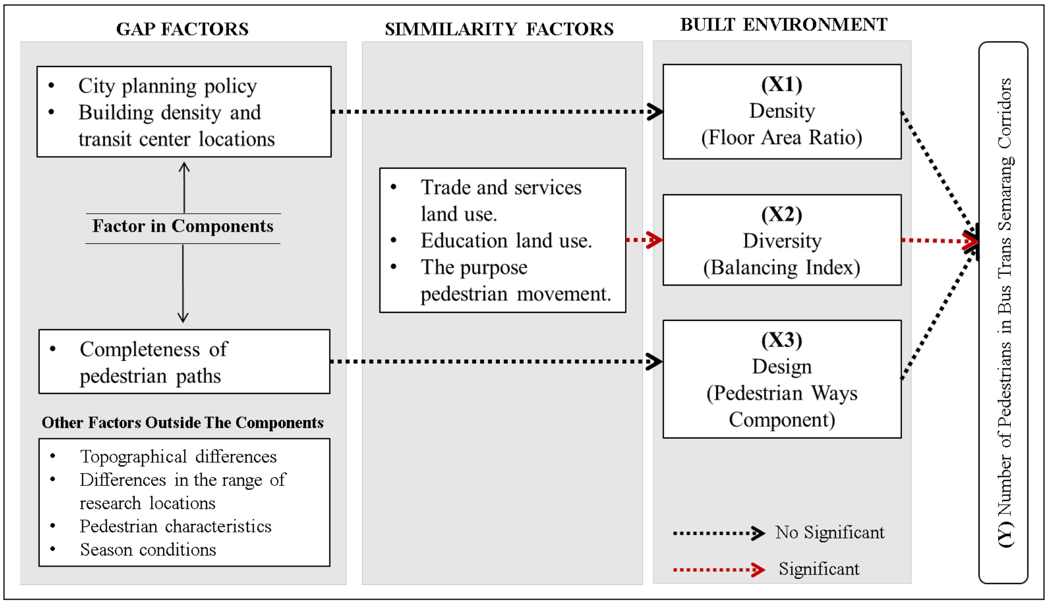

Figure 7. Model for the influence of built environment on pedestrian activity

to affect people's frequency to walk due to the diversity in their patterns of activity. The model also showed the existence of a positive relationship between the diversity variable and the frequency of pedestrians and this further indicates the ability of a higher level of balancing index to increase the frequency of pedestrians in the study area.

The two other components including density and design were, however, observed not to have any effect on how frequent people walk. Moreover, the distance between the buildings tends to be far apart due to the very minimal optimization of vertical development. The lack of pedestrian facilities along the Bus Trans Semarang corridor, especially in the city center area, is discovered to be part of the reasons the components did not have influence on the frequency to walk in the city of Semarang. There is also the fear to avoid the effect of this issue on people's desire to use transit-based transportation such as the Bus Trans Semarang. Therefore, a follow-up measure is expected to be made available to adjust pedestrians' demands to the built environment in order to create a sustainable transportation system.

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