

Analysis of Trip Generation and Attraction Due to Area Development in Surabaya (Case Study: Surabaya Waterfront Land)

Bima Santa Mulya¹, Kurnia Hadi Putra², Theresia Maria Chandra Agusdini³, Ratih Sekartadji⁴

¹²³⁴ Civil Engineering Department, Civil Engineering and Planning Faculty, Adhi Tama Institute of Technology Surabaya

¹bimasantamulya21@gmail.com, ²Kurnia_putra@itats.ac.id, ³theresiamca@itats.ac.id, ⁴ratih.sekartadji@itats.ac.id

Abstract The Surabaya Waterfront Land (SWL) area is a new development currently under construction in Surabaya. The project is conceptualized not merely as a residential area but as an integrated complex comprising various supporting facilities, including shopping centers, commercial districts, green open spaces, and public amenities. Despite these features, the project has raised concerns among nearby communities due to its perceived potential to exacerbate traffic congestion. This study aims to determine whether the extent of the residential area influences the volume of vehicular movement to and from the site, specifically in terms of trip generation and trip attraction. To achieve this, a simple linear regression model was applied, with the residential area serving as the independent variable (X), and trip generation (Y_1) and trip attraction (Y_2) as the dependent variables. The analytical results indicate that the regression model lacks statistical significance, suggesting that the residential area does not have a strong causal relationship with trip generation and attraction. The derived regression equations are $Y_1 = 1975.069 + 1.167X$ and $Y_2 = 1890.46 + 1.213X$. However, the relatively small regression coefficients compared to the intercepts imply that land area is only one of several factors influencing vehicular movement. The findings are further limited by the dataset, which includes observations from only three comparable sites. Consequently, this study provides a preliminary reference for transportation planning in the SWL area and highlights the need for further research incorporating additional variables such as commercial and educational facilities. Ultimately, it offers a foundational framework to support sustainable transportation strategies and mitigate potential traffic congestion arising from future development.

Keywords: Trip Generation and Demand, Surabaya Waterfront Land, Impact of Residential Development

1. Introduction

The first stages of transportation analysis are trip generation and trip attraction, which determine how many trips leave a zone (trip generation) and how many travel to a zone (trip attraction). Land use characteristics, socioeconomic conditions, accessibility, and the availability of transportation facilities all affect how much of this mobility occurs (Tamin, 2000). Understanding trip production and attraction patterns is crucial for modern transportation planning since it is the foundation for creating effective infrastructure and managing any traffic effects (Ortuzar & Willumsen, 1994). According to Minister of Transportation Regulation No. 17 of 2021, evaluating land use changes through trip generation analysis has grown in importance as a component of creating a Traffic Impact Analysis (ANDALALIN). To guarantee the sustainability of the transportation system and avoid congestion on the nearby road network, any development activity that could lead to an increase in mobility needs to be examined.

Previous research has demonstrated that the parameters influencing mobility are strongly influenced by the area's function. According to Ersandi and Munawar (2009), the degree of accessibility to public facilities in residential areas in Yogyakarta significantly influences the intensity of travel. In Sleman, travel is heavily influenced by educational activities, particularly during rush hours (Mahmudah, 2016). However, because people must commute to and from work, industrial districts like Bekasi Regency have a significant demand for travel (Rahayu, 2022). A study conducted at Klaten Regional General Hospital also showed that rising travel demand and attraction are directly impacted by changes in land use patterns (Wahyuningsih, 2013). These results validate that travel within a region will be heavily influenced by the spatial functions and community mobility requirements.

As East Java's commercial hub, Surabaya is still growing quickly, and part of that growth is the creation of new neighborhoods that influence how people travel. The Surabaya Waterfront Land (SWL), an integrated development area with plans to house residential and commercial buildings, public services, and green spaces, is one such strategic initiative. Mobility within and outside the city may become more appealing as a result of this development plan, which combines residential and commercial activity. Due to its coastal position, SWL is a new growth hub that may have an impact on the traffic on the local primary road network. If land use changes from open space to populated areas, it frequently results in more traffic. Therefore, in order to predict the potential for increased traffic flow due to activities occurring in SWL, a study is required. Adaptive transportation planning is predicated on a thorough understanding of travel

generation and attraction patterns to ensure that development does not worsen the quality of the urban environment or create traffic. In light of the proposed residential area, this study was carried out to determine the extent of trip generation and attraction in the Surabaya Waterfront Land region. The results of this study are expected to provide an initial overview as material for consideration in effective transportation planning and to support the implementation of sustainable urban development policies in Surabaya.

2. Method

Graha Famili, Citraland, and Pakuwon City are three wealthy Surabaya neighborhoods that were selected as comparative sites for this study because of their resemblance to SWL. The data collected consisted of primary and secondary data. Primary data was obtained by means of an *Average Daily Traffic (ADT)* study, which documented vehicles entering and exiting each site at particular times. Interviews were also conducted with residents and security guards to determine peak hours, the most prevalent vehicle types, and the main activities of road users. Secondary data on residential area size was obtained from the developer's official website and measurements taken using Google Maps. After the data was gathered, SPSS (Statistical Package for the Social Sciences) software was used to analyze it. The study employed simple linear regression analysis to ascertain the correlation between trip generation and travel demand (dependent variables) and residential area size (independent variable). The analysis's findings were utilized to develop a model for estimating travel and attractions that will be used in the SWL region.

3. Results dan Discussion

The primary and secondary data used in this study came from government sources, online observations, and direct questionnaires. To estimate trip creation and attractiveness, a regression model is developed using both types of data. The initial set of data gathered was *Average Daily Traffic (ADT)* data, which is based on how many cars enter (pull) and exit (push) each location between 6:00 and 19:00 WIB. The two days of data collection, which were weekdays and holidays, were followed by the selection of the most abundant data to depict traffic conditions. In the regression analysis, this data served as the dependent variable. In addition, the residential area of the three comparison locations, measured in hectares, served as the study's data source. This information serves as the independent variable in the analysis to determine how it affects the creation and appeal of trips.

To ascertain the impact of residential area size on regional travel demand and generation, as well as to create a prediction model that could be used for the Surabaya Waterfront Land (SWL) area, the data was then processed and examined using basic linear regression techniques.

a. Description of Trip Generation and Attraction

Table 1. Description of Trip Generation and Attraction

Location	Settlement Area (Ha)	Trip Generation (SMP/Hour)	Trip Attraction (SMP/Hour)
Citraland	1698,25	3910	3906
Graha Famili	186,02	1687	1640
Pakuwon City	315,60	2896,4	2794

The table presents data on the size of the residential area (in hectares) and the amount of trip generation and attraction (SMP/H) in the three comparison areas.

- 1) The residential area in CitraLand Surabaya has an area of 1,698.25. The area is dominated by exclusive residential clusters designed to cater to the needs of the upper-middle to premium segments of society. The clusters generally consist of landed houses, villas, and townhouses, each offering a modern residential concept with a well-organized environment. Each cluster is equipped with various supporting facilities such as parks, children’s play areas, clubhouses, and 24-hour security systems.
- 2) Graha Famili Surabaya area is one of the exclusive residential areas located in West Surabaya. The residential area in this area has an area of 186.02 hectares. The residential area consists of various luxury residential clusters, including early-stage developments as well as additional units in the form of landed houses and vertical residences such as condominiums. The area is designed with comfort, aesthetics, and good environmental management in mind. It shows that the main function is not only exclusive, but also representative of the modern lifestyle of the upper middle class in Surabaya.
- 3) The residential area in Pakuwon City consists of several residential clusters, including Palm Beach, Laguna, Florence, and others. The residential area in this area has an area of 315.6 hectares, that shows the dominance of residential functions in the area. As an integrated residential area, Pakuwon City is equipped with various supporting facilities such as education centers, shopping centers, green open spaces, and good road accessibility, thus supporting the high population movement activities.

The data shows a positive correlation between the size of the residential area and the amount of trip generation and attraction. Citraland, being the largest area (1,698.25 ha), recorded the highest generation and attraction of 3,910 and 3,906 SMP/hour. On the other side, Graha Famili, which is the smallest area (186.02 ha), generated the lowest generation and attraction of 1,687 and 1,640 SMP/hour. Meanwhile, Pakuwon City, with its medium size (315.6 ha), produces generation and attraction figures that are also in the middle, namely 2,896.4 and 2,794 SMP/hour. The equal value of generation and attraction indicates that the residential area is not only a source of outbound trips, but also attracts inbound trips in a relatively balanced amount, especially during peak hours.

b. Data Analysis of Trip Generation

1) Classic Assumption Test

a) Normality Test

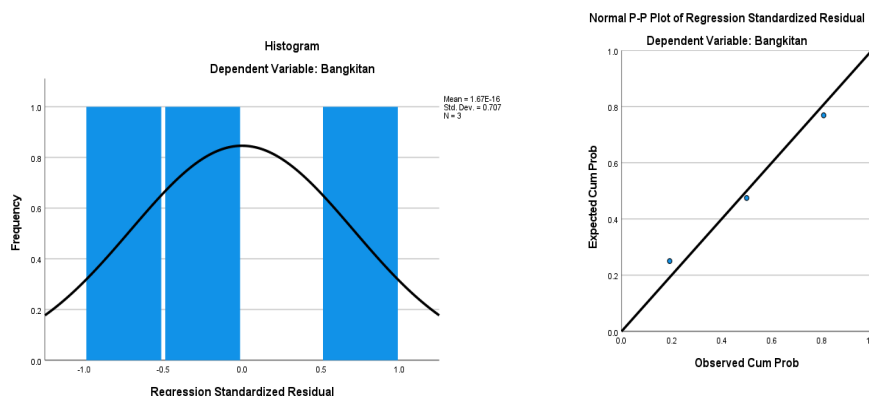


Figure 1. Histogram and P-P Plot of Trip Generation

It can be seen that the histogram graph shows a pattern that resembles a bell curve (normal distribution). This indicates that the residuals are normally distributed, thus supporting the fulfillment of the normality assumption in linear regression analysis. In addition, it can be seen

that the points on the P-P Plot graph follow the diagonal line consistently. This indicates that the residuals are normally distributed, so the assumption of normality in linear regression analysis has been fulfilled.

b) Homoscedasticity Test

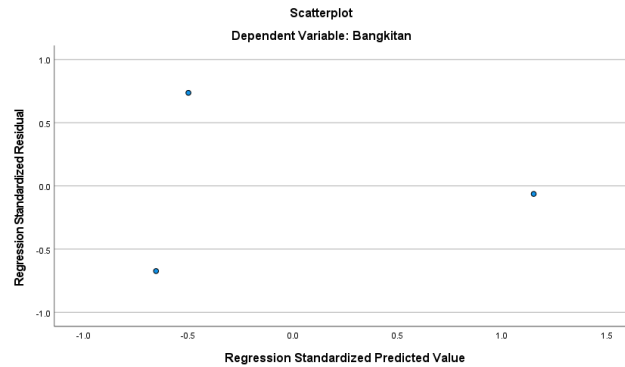


Figure 2. Scatterplot of Trip Generation

The scatterplot between the standardized predicted value and the standardized residual shows a random distribution of points and does not form a specific pattern. This indicates that the assumptions of homoscedasticity and linearity in the regression model have fulfilled.

c) Regression Analysis Results and Model Significance Test

Based on the results of simple linear regression analysis using SPSS software, the regression model is obtained in the following equation.

$$Y_1 = 1975,069 + 1,167 X \dots\dots\dots (1)$$

- Y₁ = trip generation (SMP/H)
- X = residential area (Hectare)
- 1975.069 = constant
- 1.167 = regression coefficient

Table 2. Regression Analysis Results and Model Significance Test

	Component	Trip Generation
Model Summary	R	0,879
	R Square	0,773
	Adjusted R Square	0,546
	Std. Error Estimate	750,185
Uji T: Coefficients	Constant (a)	1975,069
	Coefficient X (b)	1,167
	Std. Error	0,633
	t-value	1,844
	Significant (Sig.)	0,316
Uji F: ANOVA	F-value	3,402
	Significant (Sig.)	0,316

(1) The t-test is used to see whether variable X (housing size) has a significant effect on Y (number of movements). The results of the t test can be seen in the significant value in

Coefficients of 0.316 (> 0.05) indicating that the relationship between housing area and movement generation is not statistically significant. This may be due to the very small sample size so that the model results are not strong enough to show a valid relationship.

- (2) The F test aims to determine whether the regression model as a whole is significant. The results of the t test can be seen in the significant value in ANOVA showing an F value of 3.402 with a significance of 0.316 (> 0.05), so the regression model is not significant. This means that the housing area does not have a significant effect on the generation of movement, possibly due to the very small sample size.

c. Data Analysis of Trip Attraction

1) Classic Assumption Test

a) Normality Test

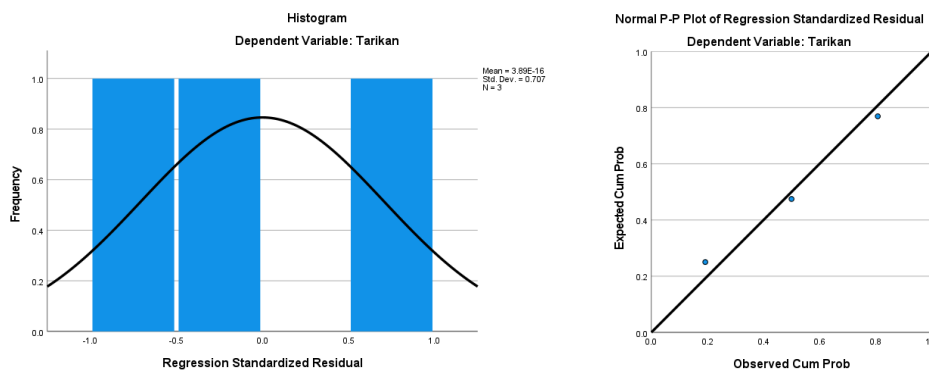


Figure 3. Histogram and P-P Plot of Trip Attraction

It can be seen that the histogram graph shows a pattern that resembles a bell curve (normal distribution). This indicates that the residuals are normally distributed, thus supporting the fulfillment of the normality assumption in linear regression analysis. Then, it can be seen that the points on the P-P Plot graph follow the diagonal line consistently. This indicates that the residuals are normally distributed, so the assumption of normality in linear regression analysis has been fulfilled.

b) Homoscedasticity Test

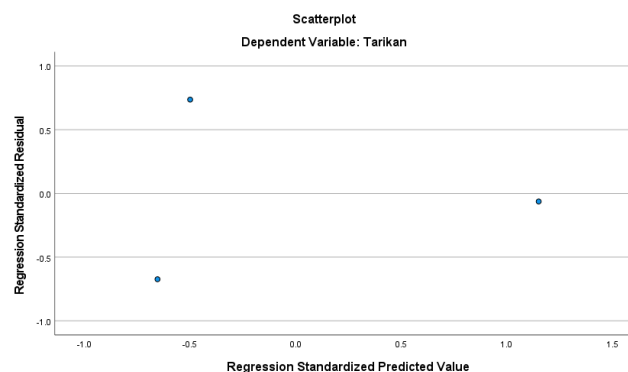


Figure 4. Scatterplot of Trip Attraction

The scatterplot between the standardized predicted value and the standardized residual shows a random distribution of points and does not form a specific pattern. This indicates that the assumptions of homoscedasticity and linearity in the regression model have been fulfilled.

c) Regression Analysis Results and Model Significance Test

Based on the results of simple linear regression analysis using SPSS software, the regression model is obtained in the following equation.

$$Y_2 = 1890,46 + 1,213 X \dots\dots\dots$$

- Y₂ = trip attraction (SMP/H)
- X = residential area (Hectare)
- 1890.46 = constant
- 1.213 = regression coefficient

Table 3. Regression Analysis Results and Model Significance Test

	Component	Trip Attraction
Model Summary	R	0,805
	R Square	0,805
	Adjusted R Square	0,611
	Std. Error Estimate	706,974
Uji T: Coefficients	Constant (a)	1890,46
	Coefficient X (b)	1,213
	Std. Error	0,596
	t-value	2,034
	Significant (Sig.)	0,291
Uji F: ANOVA	F-value	4,136
	Significant (Sig.)	0,291

- (1) The t-test is used to see whether variable X (housing size) has a significant effect on Y (number of movements). The results of the t test can be seen in the significant value in Coefficients of 0.291 (> 0.05) indicating that the relationship between housing area and movement generation is not statistically significant. This is likely due to the very small sample size so that the model results are not strong enough to show a valid relationship.
- (2) The F-test aims to determine whether the overall regression model is significant. The results of the t test can be seen in the significant value in ANOVA showing an F value of 4.136 with a significance of 0.291 (> 0.05), so the regression model is not significant. This means that the housing area does not have a significant effect on the generation of movement, possibly due to the very small sample size.

d. Surabaya Waterfront Land (SWL)

Surabaya Waterfront Land (SWL) area consists of four main blocks, namely Block A, Block B, Block C, and Block D, with dominant designations of residential, commercial, education, green open space, and public infrastructure and facilities. Although each block has a mixed designation, residential land area remains the main focus in the calculation of trip generation and attraction.



Figure 5. Master Plan of Surabaya Waterfront Land (SWL)

- 1) Surabaya Waterfront Land (SWL) block A is a multifunctional area with dominant residential uses, supported by education, health, and commercial facilities. This arrangement has the potential to generate high volumes of trip generation and attraction, especially during peak hours, given the many functions that are integrated into one block.
- 2) Surabaya Waterfront Land (SWL) block B is a multifunctional area with the main role as a aquacultures and coastal logistics center, supported by settlements and other basic services. The presence of ports, factories and commercial facilities is expected to generate a high volume of movement for both the distribution of goods and the mobility of residents and workers. This area is very important in supporting the economic activities of the SWL region as a whole.
- 3) Surabaya Waterfront Land (SWL) block C is a coastal area divided into two main sub-blocks: block C1 (west) and block C2 (east). This area is designed as an area with thematic tourism, residential, and business/financial center functions. Block C has an environmentally friendly character, indicated by the presence of a zero-emission factory and extensive green open space (RTH).
- 4) Surabaya Waterfront Land (SWL) block D is a coastal area divided into two main sub-blocks: block D1 (west) and block D2 (east). Block D is designed as a cultural and tourism-based area with balanced land use between settlements, cultural facilities and cruise ports. This area has great potential as a cultural and maritime tourism destination, supported by a natural environment in the form of mangroves, as well as social infrastructure such as worship centers, health facilities, and education.

e. Estimation of Trip Generation and Attraction SWL

Estimation of trip generation and attraction is an important part of spatial structure planning to understand the potential for future traffic and transportation infrastructure needs. This analysis is based on the type of land use, area, and main function. The estimation calculation is done by inputting the settlement area value into the regression model.

Table 4. Estimation of Trip Generation and Attraction SWL

Block	X: Settlement Area (Ha)	Y ₁ : Trip Generation Estimation (SMP/Hour)	Y ₂ : Trip Attraction Estimation (SMP/Hour)
A	42,8	$1975,069 + 1,167 \times 42,8 = 2.025,02$	$1890,46 + 1,213 \times 42,8 = 1.942,38$
B	38,2	$1975,069 + 1,167 \times 38,2 = 2.019,65$	$1890,46 + 1,213 \times 38,2 = 1936,80$
C	164,7	$1975,069 + 1,167 \times 164,7 = 2.167,27$	$1890,46 + 1,213 \times 164,7 = 1.090,24$
D	194,0	$1975,069 + 1,167 \times 194,0 = 2.201,47$	$1890,46 + 1,213 \times 194 = 2.125,78$
Total		8.413,41	8.095,20

The total generation reached 8,413.41 SMP/hour and the total attraction reached 8,095.20 SMP/hour. Although there is a significant difference in land area between blocks, the movement generation does not increase proportionally. This shows that the size of the settlement area is not the only factor that influences generation, Therefore, further analysis with other variables is needed.

4. Conclusion

The generation and attraction models for travel in the Surabaya Waterfront Land (SWL) residential area were analyzed using simple linear regression with residential land area as the predictor variable. The resulting regression equations were $Y_2 = 1890.46 + 1.213X$ for attraction and $Y_1 = 1975.069 + 1.167X$ for generation. This variable was not a major determinant of the number of movements, though, as the regression coefficient values were quite modest in comparison to the constant value, suggesting that the impact of land area on the quantity of trip generation and attraction was very minimal. Furthermore, the computation results indicate that, in spite of notable variations in land size, each residential block produces comparatively comparable trip generation and trip demand (2,019.65–2,201.47 SMP/hour). These results suggest that other variables, like population size, car ownership, accessibility, and the presence of auxiliary services, might be more important causes of travel. As a result, the model's limitations in terms of variables and sample size prevent it from being a trustworthy prediction tool just yet. To get statistically significant associations that are in line with the real movement conditions in the SWL region, more study is therefore required using a more thorough model and more representative data.

References

- Ersandi, Y, Munawar. A, R. S. A. P. (2009). Model Bangkitan Perjalanan Kerja dan Faktor Aksesibilitas pada Zona Perumahan di Yogyakarta. *Jurnal Ilmiah Semesta Teknik*, 12(1), 44–54.
- Mahmudah, N. (2016). Pemodelan bangkitan perjalanan pelajar di Kabupaten Sleman. *Jurnal Teknik Sipil*, 13(4), 301–307.
- Ortuzar, J.D. dan Willumsen, L. G. (1994). *Modelling Transport*. John Willey & Sons.
- Rahayu, Anisa Mahadita Candra, et al. (2022). Identifikasi Faktor Pengungkit Bangkitan dan Tarikan Perjalanan Kegiatan Industri (Studi Kasus Kawasan Industri di Kabupaten Bekasi). *Jurnal Teknologi Transportasi Dan Logistik*, 3(1), 23–28.
- Regulation of the Minister of Transportation of the Republic of Indonesia Number PM 17 of 2021 concerning the Implementation of Traffic Impact Analysis.
- Rumanga, A. A. (2014). *Analisis Model Bangkitan Tarikan Kendaraan Di Kota Makassar*.
- Tamin, O. Z. (2000). *Perencanaan, Pemodelan, dan Rekayasa Transportasi*.
- Wahyuningsih, Anik Rahmawati, and I. A. M. (2013). *Analisis Bangkitan dan Tarikan Perjalanan (Studi Kasus Pada Tata Guna Lahan Rumah Sakit Umum di Klaten)*. Diss. Universitas Muhammadiyah Surakarta.

