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Modeling The Generation And Attractiveness Of Passenger Demand Trips On The Madiun-Slahung Railway Reactivation Line

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Abstract. The reactivation plan of the Madiun-Slahung railway line is the main program for the development of the railway network and service stage IV in 2026-2030, as stated in the National Railway Master Plan. Therefore it is necessary to research the demand for traction and generation as well as passenger interest in the future Madiun-Slahung these shelters are reactivated. Based on the results of data analysis and discussion of the calculation of the Madiun-Slahung area, it can be concluded that the model of the reactivation area of the Madiun-Slahung railway covers 7 districts, consisting of 45 sub-districts/villages. A household survey (Household Interview) was used to produce data on travel patterns and characteristics that affect the trip. The number of trip generation ranges from 4,164 to 13,557 people/hour for trip production and from 674 to 31,359 people/hour for trip attraction. Zone 2, Kartoharjo sub-district has the highest number of trip production, while zone 4, Ponorogo sub-district has the largest number of trip attractions due to the high population, number of vehicle owners, and the strength of attraction from shops, campuses, and schools in the zone. The largest travel distribution value occurs in Zone 4,which is used for shops, government centers, Central Business Districts, offices, campuses, and schools.

Keywords: Modeling, Trip Generation, Trip Attraction, Trip Production, Reactivation Line

INTRODUCTION

The train is one of the transportation modes that can support national economic growth. The embodiment is conceived of the 2030 national railway vision, which aims to create a competitive, integrated, technological, synergized with industry, affordable railway system that can meet the development challenges [1]. The implementation of the national railway will provide reliable railway infrastructure and facilities to facilitate the mass movement of people and goods, driving national development. The railway will also be integrated with other transportation modes to reach all segments of society.

The reactivation of non-operational railway potential and the improvement of the current railway condition can increase network capacity and services, making railways the main transportation mode [1]. Planning considerations require adapted facilities and infrastructure that can carry the capacity of the region. Phase IV of the National Railway Master Plan is a major program for railway network development and services, and it aims to reactivate and revitalize the Madiun-Slahung railway line by 2026-2030. The railway track was built by Staats Spoorwegen (SS), a company

owned by the Dutch East Indies government, with a track length of ± 32.5 kilometers. From 1907 until 1984, it served as one of the transportation modes connecting Madiun City and Ponorogo City, and it was frequently used by rice and sugar cane traders to sell their produce in the market [2]. Although the railway track in some areas is covered with asphalt or buried by pedestrian paths and residential buildings, the track condition in several sections of the Madiun-Ponorogo track still exists despite several years of disuse.

The way to maximize the efficiency of a transportation system is to apply a sustainable and integrated public transportation system with other modes of transportation and coincide with good transportation management. Human activities are closely related to the transportation system, which becomes dispersed, integrated, and sustainable. The movement's interaction with many parties in many places requires the public to grow and develop according to the times. The increase in traffic movements impacts the escalation of transportation problems' complexity [3]. Railway infrastructure planning requires a model that can be used as a characteristics reference for each individual's journey with different destinations in the studied area [4]. Hence, to produce a good trip generation model, it is necessary to obtain data about trip generation and attraction. Therefore, the demand for the reactivation of the Madiun-Slahung train can be found, according to the 2030 National Railway Master Plan concerning the plan of railway infrastructure requirements.

One of the steps in planning for rail infrastructure is to analyze relevant data and information as a reference for future predictions. The study of the number of movements, mobility, and improving the quality of service will affect the quantity of the movement of both generation and attraction trips in Madiun-Slahung. The reactivation and upgrading of the railway track are directed towards the standard development of rail and bridge tonnage, thus supporting the large carrying capacity achievement. Therefore, to determine the demand, a study of the generation and attraction on the Madiun-Slahung route was conducted.

RESEARCH METHODOLOGY

The 4-step Transportation Planning Model is currently the most popular concept of transportation planning. Its stages include Trip Generation, Mode Split, Trip Distribution, and Trip Assignment. To ensure a successful model, several factors play a crucial role, such as the determination of zones and the number of samples [11]. For this research, we employed a 4-step transportation planning model to study the railroad route that will be reactivated from Madiun to Slahung. This study only calculates trip generation and attractionOur focus is on calculating trip generation and attraction. The primary objective of the movement generation stage is to create a relationship model that correlates land use parameters to the number of movements going to or leaving a zone. This model is necessary when the impact of land use and ownership of movements on the magnitude of the generation and attraction of movements varies over time. By using detailed data on movement generation rates, socio-economic attributes, and land use, this movement generation stage predicts the number of movements a person will make in each zone of origin [11].

This stage aims to study and predict the level of movement generation by by examining the relationship between movement characteristics and the land use environment. Numerous transportation studies have successfully identified a correlation between the movement size and various variables, many of which are also interrelated. Typically, this stage uses zone-based data to model the amount of movement that occurs (both generation and attraction). For example, factors such as land use, vehicle ownership, population, number of workers, population density, income, and mode of transportation used are considered. Regarding freight transport, movement generation and attraction are predicted using the attributes of the industrial sector and other related sectors [11].

The research employs descriptive quantitative data analysis to examine the relationship between variables and measure them using instruments [5]. The sample comprises randomly selected respondents from the Madiun-Slahung sub-district, which is located along a train route. The household interview method is utilized in this study, with a focus on collecting origin and destination data to uncover travel patterns and general community characteristics. This study will provide a trip generation and attraction model by calculating the total generation from the origin to the destination on the Madiun-Slahung railway track.

Research Location And Time

The division of zones based on administrative boundaries in the form of district/village and transportation terminals/stations is divided into several zones in the urban areas of Madiun and Ponorogo which affect the number of generations and attractions. It consists of 7 internal zones, 2 bus stations for the passenger the Madiun bus stations and Ponorogo bus stations, 1 freight terminal in Ponorogo, and 1 Madiun railway station. While external 3 zones,

namely the Magetan, Pacitan, and Trenggalek areas. The research location is in the Madiun to Slahung Ponorogo which is divided into 7 study areas/zones, including the sub-districts of Manguharjo, Kartoharjo, Geger, Ponorogo, Jetis, Balong, and Slahung. The following is a map of the Madiun-Slahung non-active railway track.

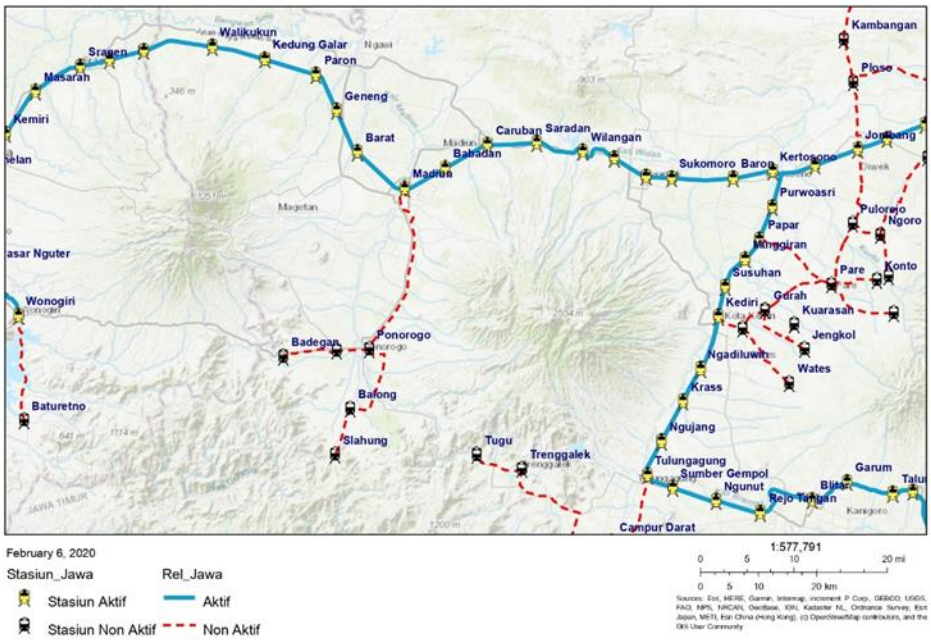

FIGURE 1. Madiun-Slahung Railway Map

Source: [6]

Collecting Data Method Data Processing And Data Analysis

The household interview survey, commonly called HIS, was used to collect the data. This survey method is reliable for determining the origin and destination of travel data, and the HIS survey results provide information on origin and destination trip patterns, as well as general characteristics that impact the trip. The descriptive perspective was used to analyze the data. The respondents were randomly selected from the Madiun-Slahung sub-district, through which the non-active Madiun-Slahung railway track passes. The objective of this study is to develop a trip generation and attraction model that calculates the total movement generated from the origin area (travel generation) and the attracted movement to the destination area (travel attraction) along the Madiun-Slahung railway track.

RESULTS AND DISCUSSION

Sample Requirement

The area has been divided based on administrative boundaries, such as sub-districts or villages and stations are in Madiun to Ponoroge, which impact the number of trip generation and trip attractions. The zone area comprises seven internal areas, including three bus stations, one freight terminal, two passenger terminals (Madiun and Ponorogo bus stations), and one railway station (Madiun Station), and three external areas, namely Magetan, Pacitan, and Trenggalek. The HIS (Household Interview Survey) was used for sampling and the sample size was determined according to the Bureau of Public Road standard calculations. This standard is appropriate for determining the number of household survey samples. Based on the survey, the comparison of the numbers multiplied with the survey's calculation results on the number of households.

To calculate the required number of research samples, we must consider the total population in the study area, which includes Manguharjo Sub-District, Kartoharjo Sub-District, Geger Sub-District, Ponorogo Sub-District, Jetis

Sub-District, Balong Sub-District, and Slahung Sub-District, with a total population of 357,046 people, falling within the range of 300,000-500,000 people. Therefore, the multiplier number should be 1/15, as per the Household Survey table for Standard Sample Size. However, we have used the minimum sample size multiplier of 1/50. Based on data from "Kabupaten Madiun Dalam Angka 2018", "Kabupaten Madiun Dalam Angka 2019", and "Kabupaten Ponorogo Dalam Angka 2019", the population density per km² in the study area is 17.270. Therefore, when multiplied by the number of multipliers 1/50, we need to have 345.4 samples, which rounds up to 346 household samples.

TABLE 1. The Standard of Household Samples Number Size

Total Population in an Area (Person)	Household Sample Size	Minimum Household sample size
< 50.000	1 in 5 household	1 in 10 household
50.000 – 150.000	1 in 8 household	1 in 20 household
150.000 – 300.000	1 in 10 household	1 in 35 household
300.000 – 500.000	1 in 15 household	1 in 50 household
500.000 – 1.000.000	1 in 20 household	1 in 70 household
>1.000.000	1 in 25 household	1 in 100 household

Source : [7]

TABLE 2. Total population

Sub-District	Total population (person)
Maguharjo	48.540
Kartoharjo	50.945
Geger	60.188
Ponorogo	77.888
Jetis	28.885
Balong	41.472
Slahung	49.288
Total	357.206

Source: [8]–[10]

The sample size for the household survey is 346 heads of households with details on the number of households for each sub-district, which is described in Table 3.

TABLE 3. Sample Size for Household Survey

Sub-District	Total population density per km²	Total of Households
Maguharjo	4.748	95
Kartoharjo	4.835	97
Geger	1.644	33
Ponorogo	3.476	70
Jetis	1.292	26
Balong	729	15
Slahung	546	10
Total	17.270	346

Travel Generation Analysis

The analysis of trip generation analysis used the Trip Generation method, which calculates the number of trips made within an area. Trip Generation consists of two stages, Trip Production (trip generation) and Trip Attraction (travel attraction) [11]. The trip production is calculated using a linear regression equation as shown in the trip generation graph, which will obtain an equation to calculate trip generation for both Motorcycles and cars. In the calculation, the amount of motorized vehicle ownership plays an essential role in determining the amount of trip

generation. The increasing number of motorized vehicle ownership in an area indicates the number of trip generation in that area.

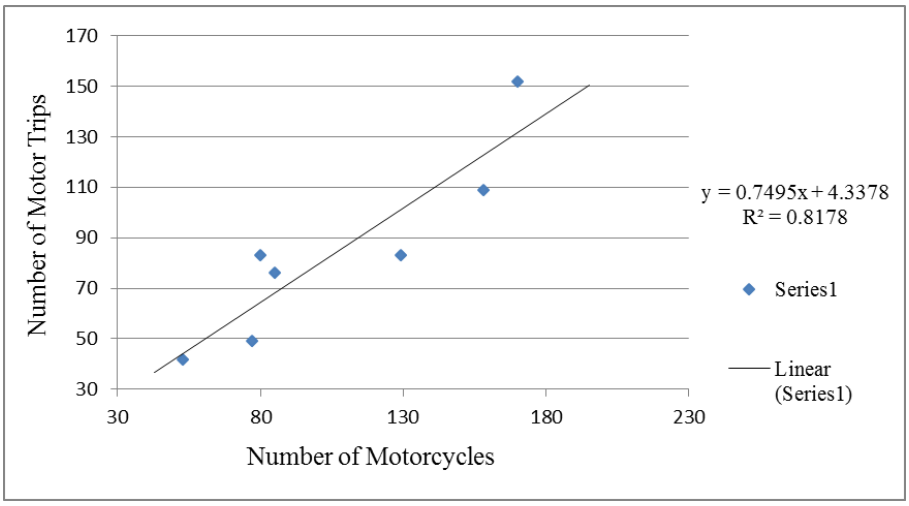

FIGURE 2. Trip Generation Graph Using Population Equation

Based on the graph above, the equation for calculating trip production is TPsm = 0.7495mc + 4.3378 with $R^2 = 0.8178$. By using the results of the linear regression equation, the formula for trip generation can be obtained. The results of the trip generation calculation are shown in Table 4.

TABLE 4. Motorcycle Trip Generation

Trip Generation/Trip Production				TPsm = 0.7495mc + 4.3378	
No	Sub-District	Region Zone	Population	Total of Motorcycles (Units)	Motorcycle Trip Production
1	Manguharjo	Zone 1	48.539	28.398	21.289
2	Kartoharjo	Zone 2	50.942	30.155	22.606
3	Geger	Zone 3	60.188	24.316	18.229
4	Ponorogo	Zone 4	77.545	27.567	20.666
5	Jetis	Zone 5	28.943	20.115	15.081
6	Balong	Zone 6	41.539	22.265	16.692
7	Slahung	Zone 7	49.350	9.265	6.948
Total			357.046	162.081	121.510

The trip attraction is influenced by the tensile strength of the zone, which is determined by the floor area of the zone, such as school buildings, offices, industries, and housing areas. Based on this description, the number of private vehicle owners influences the trip generation in the area. The more private vehicles, the more trips will be generated. The calculation results show that the Kartoharjo sub-district has the highest trip production with the result of 22.606 , while the Slahung sub-district has the lowest with 6.948. Assuming that there are two motorcycle users per vehicle, the number of trips for zone 2 in the Kartoharjo sub-district with the highest travel zone with 45.212 people/hour. According to Vukan R Vuchic's book on Urban Public Transportation System and Technology, the potential target for users of the commuter rail mode of transportation is 30% of the total demand [12]. Therefore, the number of potential trips for zone 2 in the Kartoharjo sub-district is 13.564 people/hour. Travel generation in the Kartoharjo sub-district is influenced by the number of settlements in the region. Zone 1 of the Manguharjo sub-district has a potential demand of 12.774 people/hour, generating many trips from residential communities. Ponorogo sub-district has a potential demand of 12.400 people/hour. The potential demand for the Geger sub-district is 10.938 people/hour, the Balong sub-district is 10.015 people/hour, and the Jetis sub-district is 9.049 people/hour. The Slahung sub-district has the lowest trip generation with 4.169 people/hour due to a small number of settlements and the area being dominated by hills. In contrast, the Manguharjo sub-district, Kartoharjo sub-district, and Ponorogo sub-district, the land use of

this area is dominated by dense settlements, resulting in high trip generation. The Geger sub-district, Jetis sub-district, and Balong sub-district have insufficient trip generation due to the limited number of villages in these areas.

Trip Attraction Analysis

The calculation of the trip attraction involves multiplying the tensile strength value of each sub-district area by the number of trip generations. The tensile strength value is estimated based on the total population towards public places such as schools, factories, offices, shops, etc. The survey was conducted during peak hours in the morning, and it was found that the majority of the Madiun-Slahung area is a Central Business District (CBD). he following table shows the calculation of the tensile strength value.

TABLE 5. Motorcycle Trip Attraction

Trip Attraction					
No	Sub-District	Region Zone	Tensile Strength	Motorcycle Trip Production	Motorcycle Trip Attraction
1	Manguharjo	Zone 1	423	21277	32921
2	Kartoharjo	Zone 2	321	22594	24971
3	Geger	Zone 3	39	18218	3041
4	Ponorogo	Zone 4	672	20654	52265
5	Jetis	Zone 5	14	15070	1123
6	Balong	Zone 6	41	16681	3188
7	Slahung	Zone 7	50	6939	3925
Total			1561	121433	121433

The zone 4 area, Ponorogo sub-district, has a high attraction value, with a total score of 52.265 motors/hour. It is assumed that there are two people for each motorcycle in the calculation of trip generation for trip attraction. The Zone 4 Ponorogo sub-district is the highest travel attraction zone with a total of 31.359 people/hour trips. As the center of activity and mobility for the residents of Ponorogo Regency, the sub-district is a central area with high attractiveness, such as educational activities, campuses like IAIN Ponorogo, Central Business District, government centers, offices, and shops. Manguharjo sub-district attracts 19.753 people/hour with travel attractions from various community activities like such as shopping centers Lawu Plaza Mall, Matahari Mall, Timbul Jaya Mall, office centers, and government centers. The Railway Station and Bus Station are also transportation nodes in the Manguharjo sub-district. The trip attraction for the Kartoharjo sub-district is 14.983 people/hour. This area has many universities and shopping centers, which is the attraction of traveling in the Kartoharjo sub-district. In contrast, the Slahung, Balong, Geger, and Jetis sub-district have a very small trip attraction with an average hourly trip pull of only 1.691 people/hour. These areas are dominated by settlements, which explains the relatively small travel attractions.

CONCLUSION

After analyzing and discussing the data on passenger demand calculation in the Madiun-Slahung sub-district, it was found that the number of trip generation in the range of 4.164 to 13.557 people/hour and 674 to 31.359 people/hour for trip attraction. Among the sub-districts, Area 2 in Kartoharjo has the highest total trip production, while Area 4 in Ponorogo has the highest number of trip attractions. The high total population, total private vehicle ownership, and tensile strength in these areas are due to the presence of shops, campuses, and schools. The highest travel distribution occurs in Area 4, which is attributed to the presence of government centers, shops, central business districts, offices, campuses, and schools.

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