Determining The Location of Additional Facilities Train Station Based on Railway Distribution Using Geographic Information System (Case Study: Jatinegara Station – Cikarang Station)

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ABSTRACT

Trains are a mass transportation system that has existed for a long time. The condition of the train density needs to be considered because train transportation benefits people who will travel. The parameters analyzed include the train railway, signaling, total passengers and facilities of each station. The methods used are overlay, buffer, and intersection methods. Based on the results of the analysis, the most passengers are 24,998 passengers at Bekasi station with a station area of 15.838m2 and the smallest passengers are 3,315 every day with an area of 2.139 m2 at Telaga Murni station. Facilities at large stations and at small stations are mostly the same in accordance with Minister Regulation number 3 of 2011 and what distinguishes each station is based on the weight class of the station. Analysis using buffers aims to analyze the level of passenger density at each station and existing facilities by visualizing them using a Web Map. The adding facilities that need to be added and evaluated include an ATM and adding the parking park in each station.

INTRODUCTION

Trains are a mass transportation system that has been around for a long time. According to Kereta Api Indonesia Press Release (2022), in one trip, train can consist of 8 to 14 passenger train cars with a capacity of up to 1,120 seats. Compared to a private car with a total of 7 people or a motorcycle with a capacity of 2 people, one train trip can replace 160 cars or 560 motorcycles[1].This condition is based on data from the Central Bureau of Statistics (BPS in Indonesia) in 2022 that the additional number of train passengers in Jabodetabek (Jakarta, Bogor, Depok, Tangerang, Bekasi) from 2021 to 2022 reached 70,000 passengers[2]. To support punctuality, headway, and who must make cross capacity calculations at each crossing, there are still many excessive passenger accumulations due to the inappropriate number of facilities with the number of passengers. These problems need to be overcome by synchronizing the number of facilities and infrastructure of the railway and the station.

Public transport performance is the work of public transport that runs to serve all community activities in traveling and activities. Some parameters that are used to measure public transportation's operational performance include travel time, stopping time, and load factor [3]. The condition of the train density needs to be considered because rail transportation benefits people who will travel more. What needs to be reviewed is the train railway, signaling, and technical train departures and arrivals. The density occurs during peak hours from 05.00 to 09.00 in the morning and from 16.00 to 21.00 at night.

In this research, a spatial analysis of traffic density from Jatinegara Station to Cikarang Station was performed. The data used is divided into spatial data and non-spatial data. Spatial data in the form of shapefiles of railway track visualized with the quad line data and shapefile data of railway stations. The non-spatial data consists of train data. Furthermore, the calculation of area station density is obtained based on the number of passing trains and the distance between stations using a schedule from PT Kereta Api Indonesia. The buffer method uses GIS using QGIS software, which helps analyze train stations in the form of train headways, station capacity, number of signaling, trains passing through the station, and trains stopping at the station.

The result of this research is information about the train line and additional train station facilities at each station. The resolution of the above problems will focus on how the expansion and effectiveness Station information using Geographic Information System (GIS) tools, analyzing how many stations from Jatinegara to Cikarang and train passengers who board or alight from

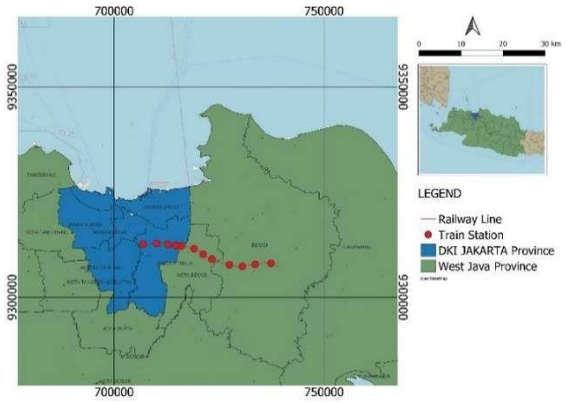


Figure 1 Research Location Map.

Jatinegara Station to Cikarang Station that can accommodate trains in accordance with the expansion of the station. The results of which will be presented in the form of an analysis of train station facilities using a Web Map.

RESEARCH METHODOLOGY

A. Research Location

The research location map which in from Jatinegara Station to Cikarang Station where the stations are 38 km and located in 6°12'53”- 6°15'18 of south and 106°52'13” - 107°08'42” of East included DKI Jakarta, Bekasi City and Bekasi Regency which is explain in figure 1.

B. Data and Equipment

a) Data

The data used in the final project are as follows:

1) Data of boundaries map of the administrative areas of East Jakarta, Bekasi city and Bekasi Regency.
2) Data of digital Railway map, train signal location and train station location from Jatinegara to Cikarang based on PT. Kereta Api Indonesia.
3) Data of Total Passengers in each station between Jatinegara to Cikarang Station from PT. Kereta Commuter Indonesia (PT.KCI).
4) Departure and Arrival Schedule of trains from the KAI Access application and the Number of Passengers at the Station between Jatinegara to Cikarang.

b) Equipment

The equipment used in the final project are as follows:

1) Laptop Asus Vivo Book UU7PU69B as the main hardware for processing data.
2) Quantum GIS (QGIS) Software for processing information systems from data input, data processing, data analysis and displaying results.
3) Microsoft 365 to make a report and presentations.

C. Processing Data Phase

Based on processing phase, the data prepared in this research is based on accordance with the Minister of Transportation Regulation number 33 of 2011 concerning Types, Classes, and Activities at Railway Stations, necessary to use data such as spatial data and non-spatial data [4]. Spatial data is referenced data geographic over the representation of objects on earth. Spatial data has two types of types are vector and raster.

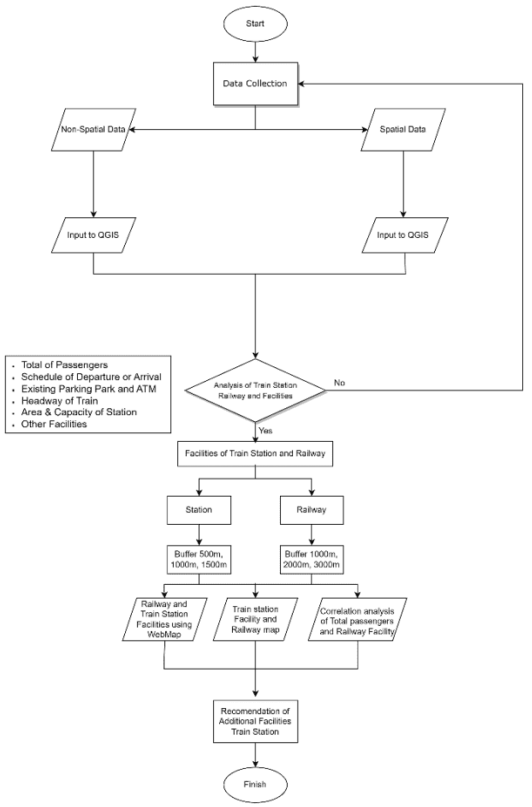


Figure 2 Processing Data Phase Chart.

Data model vectors display, place, and store spatial data by using dots, track or curves, or polygons along with their attributes [5]. For spatial data, it includes railroad tracks that are in shapefile format and marked with line symbols, railroad signal location shapefiles that are marked with circle symbols, and railroad station shapefiles and railroad station facilities that are in the form of long square areas.

The input of the non-spatial data attribute table is the train departure schedule, train passing schedule, train arrival schedule and facilities. After that, the three non-spatial data are overlaid and become the non-spatial data attribute table. After inputting the attribute table, then overlay the data with spatial data, namely train track, train signal locations, train stations, and train station facilities.

Data that has been overlayed is then analyzed based on Track Analysis and Railway Station Facilities. Then, the requirements of this analysis are Station Safety, Station Security, Station Regularity, Station Comfort, Station Convenience, and Station Equality or class.

Analysis of railway track and railway facilities such as railway station facilities and infrastructure, distribution of existing parking, number of passengers, passing trains, trains that stop, headways and station area capacity. If the analysis has not been fulfilled, then data collection will be carried out again. If successful, then this research produces information about train tracks and stations. Spatial analysis with the buffer method on train station facilities to get the coverage area of each station facility and railroad line to railroad passengers and find out the affordability of passengers at each station-to-station facilities and railroad track. After that, the analysis of the Distribution of Railway Station Facilities, Railway and

Table 1 Total Passengers, Area Capacity and Headway of each station

Name of Station	Total Passengers	Area Capacity (m^2)	Headway (Mins)
Cikarang	14.767	9.526	7.404
Telaga Murni	3.315	2.139	5.604
Cibitung	4.410	2.825	6.804
Tambun	9.074	5.806	5.804
Bekasi Timur	6.123	3.905	4.604
Bekasi	24.998	15.838	5.004
Kranji	9.242	5.914	4.404
Cakung	8.516	5.450	2.644
Klender Baru	6.201	3.908	2.704
Buaran	5.927	3.798	5.706
Klender	6.690	4.281	5.404
Jatinegara	7.433	4.757	4.413

Source: (PT. Kereta Commuter Indonesia,2023).

Facilities visual using Web Map, analysis of the Correlation of the Number of Passengers with Trains and train station facilities as described in the flow chart in Figure 3.

D. Inputting and Processing data with Quantum GIS

Inputting spatial data in the form of shapefile data consists of 3 (three) types of data, namely Shapefile of railway, Shapefile of Train signal location and Shapefile of Train station facility. The shapefile inputting process in GIS is processed with Quantum GIS software with the following steps:

1) Click on the "Layer" menu, mouse-over "Add Layer" and click "Add Vector Layer…" You can also click the "Add Vector Layer" button in the left column of QGIS.
2) If the shapefiles you have are on your local machine, all you need to do is click on the Browse button and navigate to folder that you make shapefiles is.
3) After you find the folder with your shapefile, you will be sure the data type is selected to shapefile. Then, click the drop-down box next to file name and select ESRI shapefiles (.shp or *SHP). You have many different vector data types to choose from if you have another data type, after that you can click open them.

For inputting non spatial data in the form of txt.file data or Csv.file data consists of 4 (four) types of data namely Railway facilities and Train station Infrastructure, Train departure and arrival, Train passed on train station, Total of passengers. The process of inputting data attributes in GIS is processed with Qgis software with the following stages:

1) Prepare the csv files format, then click on the layer Click on the "Layer" menu, mouse-over "Add Layer" and click "Add Vector Layer…" You can also click the "Add Delimited Text Layer" button in the left-hand column of QGIS.
2) The next GUI will have many different options to change depending on the specific data set. The outline of most common fields needs to be changed.
   a) Browse – click on Browse and find the folder where the csv file is saved and open the file.
   b) Layer name – the name of the CSV will show up.
   c) File Format – depending on the version of QGIS user. You may need to verify the file format.
   d) Geometry definition – If you have x,y coordinates you will choose the "Point Coordinates" option. Verify the X field is pointing to your Longitude field and the Y field is pointing to your Latitude Field. If you have a table with no x,y coordinates you will choose the "No Geometry" option.
   e) Layer settings – you will see a preview of the table. Verify that everything looks correct, then click ok.
3) If you have a field with no x and y coordinates you are done importing the csv file. However, depending on the version of QGIS using, you may be prompted to define the coordinate reference system (CRS) of your x and y coordinates. Longitude or Latitude coordinates are unprojected and should choose the CRS of WGS 84 (EPSG:4326). If you have coordinates using something else, like meters in a UTM zone, search for using the filter box in the CRS selector Dialog.

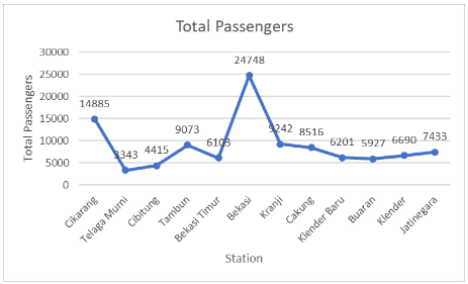
E. Add Shapefile with Quantum GIS

After the spatial and non-spatial data is combined, it results in spatial data that is complete with attributes. The next process is the merging of several shapefiles into 2 (two) groups, namely the merging of Train station facilities and Railway infrastructure. The merging of these shapefiles in the QGIS software goes through the following stages:

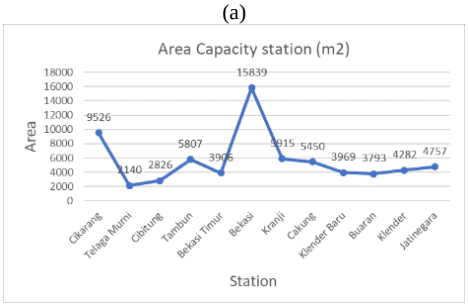
1) Before the shapefile data is merged, it is necessary to equate the data type in each shapefile that will be merged. This data type is CRS (map projection), the size and type of each field must be the same.
2) In other words, looking the merger polygons or attribute of the same layer, the similar way of merging vector layers found at Vector >>> Data Management Tools >> Merge Vector Layers.
3) Choose shapefile to be merger.
4) Fill in the name of the result merger shapefile.

F. *Buffer Quantum GIS and Intersection*

The buffer and intersection methods for train station facilities and railway infrastructure in the buffer are as follows:



(a)



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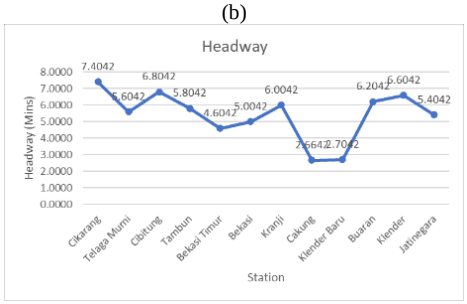

(c)

Figure 3 (a) Graph of Passengers, (b) Graph of Area Capacity, and (c) Graph of Headway.

1. Train station facility using buffer analysis 500 m, 1000 m dan 1500 m.
2. Railway infrastructure using buffer analysis 1000 m, 2000m dan 3500 m.

At this buffer phase using features from QGIS for the Buffer and Intersection methods, where Buffer is used to create a coverage area for each buffer while Intersection is used to combine the intersection between buffer coverage with shapefile train station facilities and railway infrastructure. The Buffer stage in QGIS is as follows:

1) Open vector menu > geoprocessing > buffer
2) Input vector layer, Choose the layer want to make the buffer (in this choose ……), For Buffer distance fill the distance of buffer, For Output Shapefile, Choose the file based on the buffer output.

After the buffer area is created with a certain area, the next step is Intersection. The intersection stage in QGIS is as follows:

1. In Toolbar menu, click vector, select Geoprocessing Tools, and click Intersection.
2. In the Input layer section, browse and select data.
3. Select overlay layer.
4. Optionally you can choose Input and Overlay fields.
5. Choose destination to save output file.
6. Click Run to complete.

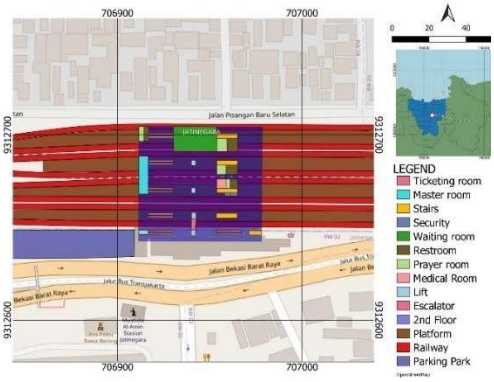

Figure 4. Jatinegara Train Station Facilities Map.

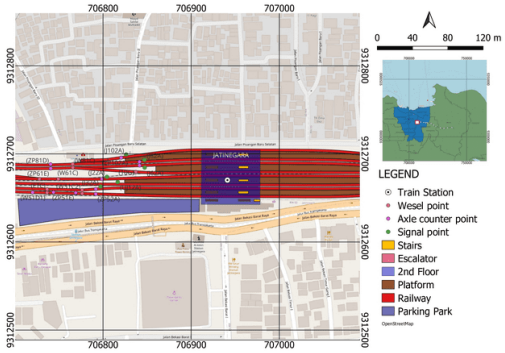

Figure 5. Jatinegara Railway Facilities Map.

RESULT AND ANALYSIS

A. Train Passengers, Area Capacity and Headway

Train passengers are increasing from year to year in terms of passengers or area capacity at Jatinegara station to Cikarang station. Based on data from PT Kereta Commuter Indonesia (KCI), the most passengers at Bekasi Station and the least at Telaga Murni Station. To find out the headway and area capacity of each station, calculations are needed in equations 1 and 2. The guide track in this calculation is based on Ministry of Transportation in 2011 and calculations from Supriadi in 2008.

To find out the headway and area capacity of each station, calculations are needed in equations 1 and 2. The guide track in this calculation are based on PT Kereta Api Indonesia in 2012 and calculations from Supriadi in 2008 [8].

$$\boldsymbol{H} = \frac{180 \text{ x B x } 60}{\text{V}} + 0.25 \qquad (1)$$

Where:

H = The shortest time interval between two consecutive trains (Headway)
B = The distance between plots of Station A to Station B
180 = The distance after signal block service
V = The train speed

$$\text{L} = 0.64\text{m}^2/\text{ people x V x LF} \qquad (2)$$

Where:

L = The area of wide service and public service (m^2)

Table 2 Facilities of station and railway at Jatinegara Station

Facilities	Quantity
Prayer Room	3
Security Room	1
Stationmaster Room	1
Parking Park	1
Market	1
Restroom	4
Ticketing Room	1
2nd Floor Building	1
Medical Room	1
ATM Center	1
Axle Counter Point	28
Wesel & Signal point	14/12
Train Stop / Train non-stop	255/51
Headway (Mins)	4.913

Source: (PT. Kereta Commuter Indonesia,2023).

Table 3 Facilities of station and railway at Cakung Station.

Facilities	Quantity
Prayer Room	1
Security Room	1
Stationmaster Room	1
Parking Park	-
Market	-
Restroom	2
Ticketing Room	1
2nd Floor Building	1
Medical Room	1
ATM Center	-
Axle Counter Point	-
Wesel & Signal point	4/4
Train Stop / non-stop	210/82
Headway (Mins)	4.324

Source: (PT. Kereta Commuter Indonesia,2023).

V = The total of average passengers in each peak hour in one week

LF = load factor (85%)

0.64m^2 = Variable area in 1 people

B. Analysis of Facility and Railway of Station

Creating a map of railway facilities and track from Jatinegara station to Cikarang station is made based on 5 stations with the highest number of platforms and passengers, namely Jatinegara station, Cakung station, Bekasi station, Tambun station and Cikarang station.

1. Jatinegara Station

Jatinegara Station is one of the train stations located in Jakarta, Indonesia. This map of tracks and facilities at Jatinegara Station was obtained from a survey of the station. There are several facilities that were not operating at the time of the survey, namely the availability of minimal ATM's and parking lots that are currently still not operating at the station. The results of the analysis of railway tracks and results of the analysis of railway tracks and facilities at Jatinegara Station are for the station class in accordance with Ministerial Regulation number 3 of 2011 amounting to 72.3%. and belongs to the class of large stations. For more information related to existing facilities at Jatinegara station, it is explained in table 2. For sketch of the facilities and the railway at Jatinegara Station described in Figure.

2. Cakung Station

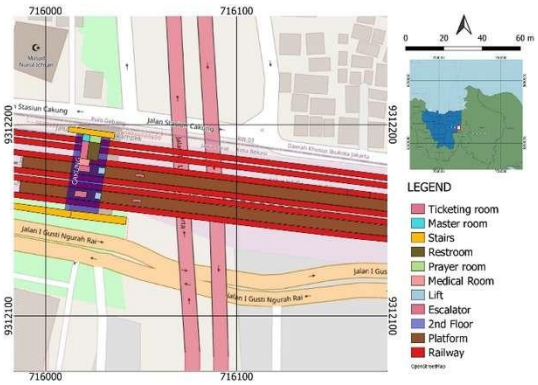

Figure 6 Cakung Train Station Facilities Map.

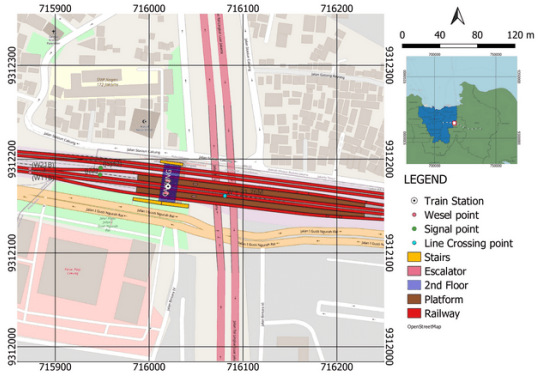

Figure 7 Cakung Train Station Railway Facilities Map.

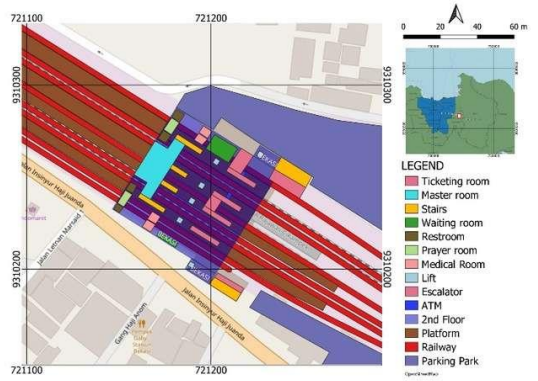

Figure 8 Bekasi Train Station Facilities Map

Cakung Station (CUK) is a located at an altitude of +18 m, is included in the Jakarta Operational Area I serves the KRL Commuter Line route train station This station is also a busy station with a very large number of passengers in the morning and evening during commuting and commuting hours. The map of tracks and facilities at Cakung Station was obtained from a survey of the station and analyzed the station. The results of the analysis of facilities and railway track at Cakung station are for the Cakung station of 69.8% and included in the medium station class. For more information regarding the facilities at Cakung station, it is explained in table 3.

3. Bekasi Station

Bekasi Station (code: BKS, +19 m) is a train station located on Jl. H. Juanda, Bekasi City, West Java. As a station located in Jabodetabek, this station serves thousands of commuter passengers every day to Jakarta. The track map and facilities at Bekasi Station were obtained from direct survey results to the station. The results of the analysis of facilities and railway track at

Table 4 Facilities of station and railway at Bekasi Station.

Facilities	Quantity
Prayer Room	1
Security Room	1
Stationmaster Room	1
Parking Park	1
Market	1
Restroom	2
Ticketing Room	3
2nd Floor Building	1
Medical Room	1
ATM Center	1
Axle Counter Point	26
Wesel & Signal point	17/17
Train Stop / non-stop	137/67
Headway (Mins)	6.504

Source: (PT. Kereta Commuter Indonesia,2023).

Table 5 Facilities of station and railway at Tambun Station.

Facilities	Quantity
Prayer Room	2
Security Room	1
Stationmaster Room	1
Parking Park	1
Market	-
Restroom	2
Ticketing Room	2
2nd Floor Building	1 (Not Operated)
Medical Room	-
ATM Center	-
Axle Counter Point	32
Wesel & Signal point	17/18
Train Stop / non-stop	122/82
Headway (Mins)	6.804

Source: (PT. Kereta Commuter Indonesia,2023).

Bekasi station is for the Bekasi station of 80.5% and included in the large station class.

For more information related to the facilities at Bekasi station, it is explained in table 4.

4. Tambun Station

Tambun Station (TB) is a train station located in Mekarsari, Tambun Selatan, Bekasi. The station, which is located at an altitude of +19 m, is in Jakarta Operational Area I. Tambun Station has 4 Train Railway on the North and Two Train Lanes on the South (Ground-Buried Track). Currently, Tambun station is undergoing repairs for better service. The map of the track and facilities at Tambun Station was obtained from the results of a survey based on the station. The results of the analysis of facilities and railway track at Tambun station are for the Tambun station class of 56.5% and are included in the medium station class.

Based on the results of survey to the station, Tambun Station is a station that is still undergoing new building work at Tambun station and at the time of the survey writer to the station, passenger mobility uses the temporary station building where the facilities in the temporary station building are very minimal such as ticket places, parking lots, restrooms and temporary prayer places that do not accommodate the current number of passengers.

5. Cikarang Station

Cikarang Station (CKR, +18m) is a train station located on Jl. Cikarang Station, Karangasih, North

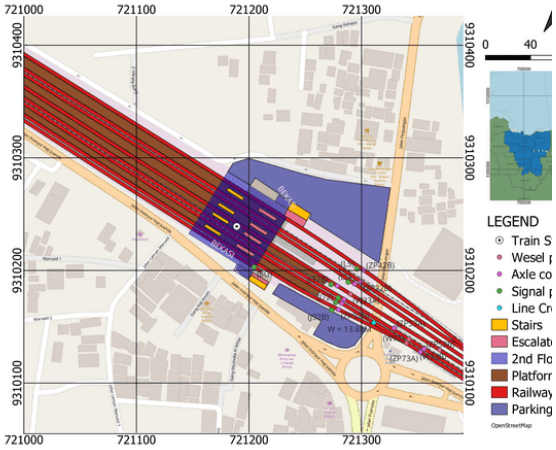

Figure 9 Bekasi Train Station Railway Facilities Map.

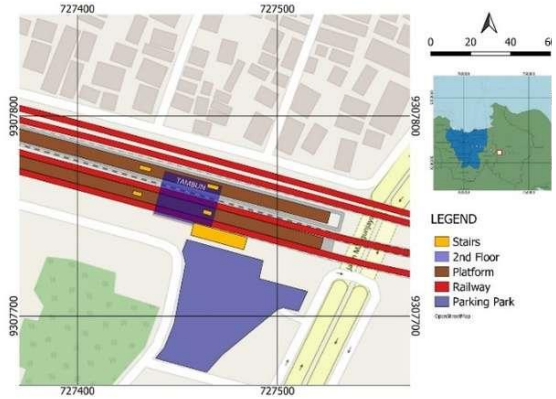

Figure 10 Tambun Train Station Facilities Map.

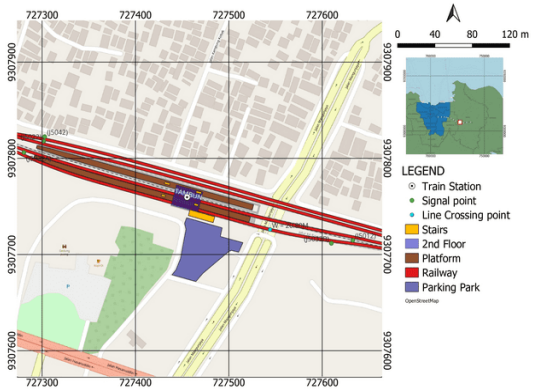

Figure 11 Tambun Train Station Railway Facilities Map.

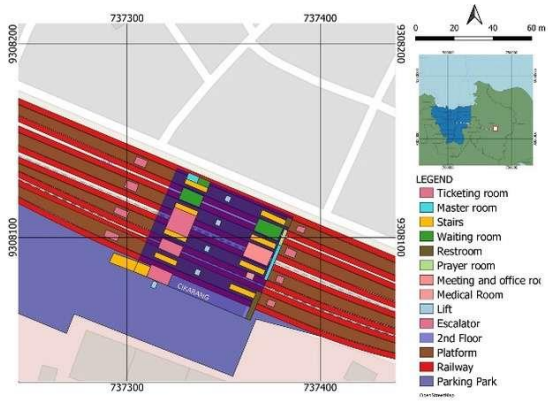

Figure 12 Cikarang Train Station Facilities Map.

Cikarang, Bekasi. Cikarang Station has 8 tracks, 4 track are turning track and 2 track are straight lanes and 2 track to train storage track. The map of the path and facilities at Cikarang Station was obtained from the results of a

Table 6 Facilities of station and railway at Cikarang Station.

Facilities	Quantity
Prayer Room	2
Security Room	1
Stationmaster Room	1
Parking Park	1
Market	1
Restroom	4
Ticketing Room	2
2nd Floor Building	1
Medical Room	1
ATM Center	-
Axle Counter Point	32
Wesel & Signal point	17/18
Train Stop / non-stop	137/67
Headway (Mins)	6.504

Source: (PT. Kereta Commuter Indonesia,2023).

direct survey to the station. The results of the analysis of facilities and railway track at the station Cikarang is for the Cikarang station class of 77.5% and is included in the large station class.

For more information related to the facilities at Cikarang station is explained in table 6.

C. Buffering Station and Railway

Based on the results of the author's research, the analysis uses buffers used with distances of 500m, 1000m and 1500m for railway station facilities and 1000m, 2000m and 3500m for railway infrastructure. By creating buffers, so these graphically formed zones are used to identify the spatial proximity of a map object to objects who are in the vicinity. By creating a Buffer as well, an area will be formed that covers or protect a spatial object on the map (buffered object) with a distance certain.These parameters based on pribadi (2008), the process of preparing and processing spatial data can be found. To get the value of the distance unit for the purposes of the buffer process cannot only be based on the size of the location distance. There are other factors that cannot be ignored, including the number of passengers and the number of train frequencies[9]. Based on the analysis of the point, it is used to analyze the density of passengers from the distance where passengers come from to reach the station. This is so that passengers can reach stations that are closer to the original passengers such as passengers can choose a station that is closer and not aimed at a station with a wider and complete space capacity. In addition, even distribution of passengers at small stations is also useful for more even passenger capacity and more effective train passenger carrying capacity.

D. Data collection visual using Web Map

Web Map visual display in Quantum GIS which aims to identify each station which includes facilities and signaling and record train information, train schedules and passenger data at each station and area capacity at each station. With this interactive display, it can make it easier to record and find out train information with visuals and data. The WebMap can access in https://fakhridesrisanr.000webhostapp.com/#13/-6.2201/106.8983. or Home (builder-preview.com).

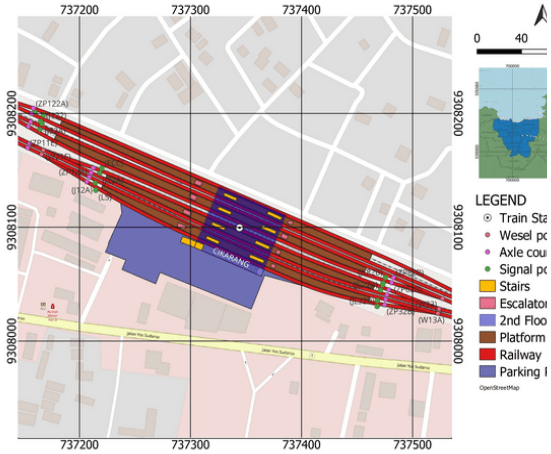

Figure 13 Cikarang Train Station Facilities Station Map.

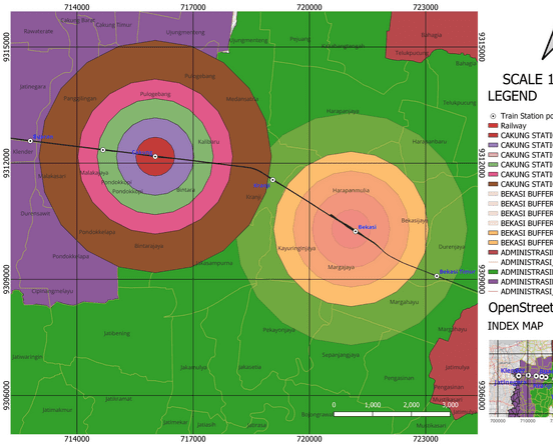

Figure 14 Buffer Distribution of Train Station Map.

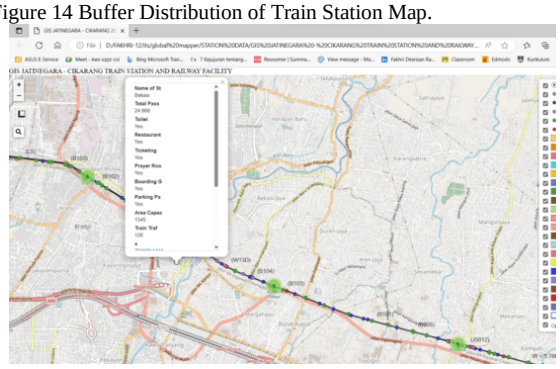

Figure 15 Visual data using Web Map.

CONCLUSION

Based on the results and analysis of the research of Determining the Addition of Train Station Facilities based on railway distribution, the authors have several conclusions. First, the total passengers from Jatinegara station to Cikarang station in each day with the most passengers amounting to 24,988 passengers located in Bekasi Station and the least passengers amounting to 3,315 passengers in one day located in Telaga Murni Station. Second, In the analysis using the buffer method shows that passengers who come from 1 place or sub-district can reach more than 1 station, it aims to map that the passenger can choose a station with fewer passengers. Third, the visual mapping using Web Map aims to make it easier for passengers in accessing facility data, train information by schedule the train, identified in each

station on the Station line Jatinegara to Cikarang station as many as 12 stations and equipped with pictures of the condition of the station and the facilities at the station. Fourth, there are some supporting facilities that have differences such as the existence of facilities in large class stations that are more than the existence of facilities in small stations. In addition, there is still little intermodal integration such as connections with buses and other public transportation as well as supporting facilities that are still small, especially at small stations such as ATM's, parking lots to the existence of restaurants and hotels. Last, the number of train frequencies at Jatinegara station to Bekasi is much more than from Bekasi station to Cikarang station which results in the accumulation of passengers at Bekasi station as a transit station to go to Cikarang station. In addition, the number of trains carrying different coaches such as 8 coaches to 12 coaches especially to Cikarang station which carries 8 coaches and total passengers at Bekasi station which is much more passengers than at other stations.

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