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Original research article

Evaluation of accessibility commuter-line station with jitney transportation modes by using GIS application: a case study of Depok Station

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ABSTRACT

This research aims to evaluate the aspects that can increase the Station's service area by maximising the integrated Jitney as the other public transportation modes that can increase reachability for the people near the Station. Evaluating the accessibility of some stations in the Depok area is needed to identify the infrastructure upgrading priorities, such as providing pedestrian roads and giving better access to the Station to increase the Station's service area. The methodology used in this research is analysing method using a GIS application to assess and discover the pattern of travel behaviour for public transport in the Depok municipality area. The GIS Database Design in this research uses the Spatial Database and Attribute Database, which are integrated with the QGIS application to become Maps for the service area of public transportation in the Depok Municipality. The road network in Depok municipality is dominated by the jitney route as intracity public transportation, which travels on the arterial and collector road. Then the railway is located in the central area of Depok that stretches from South to North. There are some areas that do not have access to jitney services due to this residential area being far from the arterial and collector road travelled by Jitney. Looking at its planning for jitneys in the Depok area, the availability of jitneys follows the demand of the passenger population, and there are no travel analyses from the Transportation Department of Depok Municipality or local public transport organisations (ORGANDA) as private jitney operators. The ineffective jitney route planning is the other reason that there are some uncovered residential areas from public transport access. Subsequently, there are different travel time characteristics among four commuter line stations in the Depok Municipality area. The Citayam and New Depok Stations have wider access for pedestrians which these two stations have a more extensive service area than Old Depok Station, whereas Old Depok Station has restricted access to the west area of this Station. The rearrangement of the Station access is needed, especially for Old Depok Station, by adding road access on the west side to increase the service area of the Station.

1. Introduction

Developing, managing, and improving integrated transportation services in the largest metropolitan agglomeration area of Jakarta, Bogor, Depok, Tangerang, and Bekasi (Jabodetabek), is the biggest challenge in this Indonesian region compared to the other areas. The congestion problem in the main road areas is caused by using many private vehicles, inadequate road capacity, behavioral and habitual factors, and lack of infrastructure development (Sudrajat, 2019).

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Another cause of congestion in the Jakarta area is that public transportation operation is not optimal in terms of route, schedule, and integration with other public transportation, which increases private vehicle users (Sitorus, 2019). Changing commuters' public transport mode is the other solution to reduce private vehicle use that causes congestion. We have several kinds of rail-based modes in Jakarta, such as commuter-line rail, Mass Rail Transit, and Light Rail Transit. Railroad public transportation has advantages over road-based transportation modes, which generally cause arterial roads or highway congestion, transportation domination in Jabodetabek far outweighs rail transportation usage. This phenomenon's main problem is that the access from passenger residences to the nearest commuter-line stations is unreachable. Unreliable public transport, such as jitneys and minibuses, to connect their home to the Station is the main problem for people choosing a private car or motorcycle

There are two classifications of public Transportation in Depok Municipality: intracity and intercity public transportation modes. The intracity public transportation use jitney to serve people's travel needs in the Depok area with a short distance route (mostly below 20 Km). Jitney is operated by private-individual ownership or private enterprises with the exact route that the local government has determined. Jitney has the main function of feeder transportation. The Jitney takes passengers from public areas such as traditional markets, residential areas, and Sub terminals, then delivers them to the larger vessel for further transportation such as commuter lines or buses.[2]

According to the Department of Transportation West Java Province **t**here is 1546 jitney that operates on 20 route in Depok Municipality (data was taken in 2022). Moving on to intercity public transportation, commute people depend on the commuter line for their daily travel activity, such as to the CBD area in Jakarta or the other area around Depok Municipality (Bekasi, Tangerang, and Bogor Municipality). The commuter line in the Jabodetabek area consists of eight to twelve trainsets for each train. Each car can serve 74 people, and the total number of daily passengers in the Jabodetabek area is approximately 1,5 to 1,9 million passengers per day (BPS-Indonesia Bureau Statistic). In the Depok Municipality, four railway stations are located in the Depok area: Pondok Cina Station, New Depok Station, Old Depok Station, and Citayam Station. These stations are integrated with Jitney as the other option for public transportation to connect the commuter line station to the other area around Depok Municipality.

Regarding geographic position, Depok Municipality, located in West Java Province on the southern border of DKI Jakarta Province, has the following boundaries: North DKI Jakarta Province, West – Tangerang Regency, South, and East – Bogor Regency. Astronomically, the Depok location is between 6° 23' 8.1204" South Latitude and 106° 47' 39.266" East Longitude. This city has 11 administrative districts with a total population of 2,056,400 people and an area of 200.3 Km2, so the population density of this area is around 10.2 people/m2.

From the BPS-Indonesia Bureau Statistic, Depok unicipality is the highest proportion of commute activity in Indonesia (Data taken in June 2020). Of the two million population in Depok, 18.52% do a daily round-trip activity to their office or school. By evaluating the accessibility of some stations around the Jabodetabek area, we can identify the infrastructure upgrading priorities, such as providing pedestrian roads and giving better access to the Station to increase the Station's service area. Moreover, for passengers whose residents cannot reach the Station by walking, we can analyse how to increase the performance of jitneys or minibuses and suggest which route can increase efficiency and reachability from the high-density area to the nearest Station. By evaluating the aspect of travel time and cost of Jitney or minibuses that operate to the station areas, we can get a broad view of what aspect needs to improve by this public transport mode.

According to the condition described above, the main purpose of this research is:

1) Analyse the integration between rail and land public transportation based in Depok Municipality.
2) Analyse the service area of public Transportation in Depok Municipality by using the GIS application.
3) Examine the residential area covered and uncovered by Public Transportation in Depok Municipality.
4) Identify the relationship of the service area to the occupancy of the passenger in the Public Transportation in Depok Municipality.
5) Improve the best transportation route model to increase accessibility and widen the service area for passengers.

2. Material and Methods

The methodology used in this research is analysing method using a GIS application. GIS helps us assess and discover the pattern of travel behaviour for public transport in the Depok municipality area. According to Azad (2015), there are two data classifications framed in the GIS system: Spatial and Non-Spatial data. These spatial analytics will help us understand the residential area covered by urban transport and the other area uncovered by urban transport. Then, the service area for the public transportation (commuter-line station and Jitney) that we found from the spatial analysis will be evaluated. The evaluation of the public transportation service area includes the accessibility of the passengers for 5, 10, and 15 minutes of walking to

reach the commuter-line Station. For jitney accessibility, we evaluate 20 different routes in and around the Depok area (D.01 to D.107 route) and the accessibility of the area for 5, 10, and 15 minutes of walking from their residential area to the road covered by Jitney. The high or low Accessibility of public transport for Commuter-line and Jitney will be determined by how long the passengers can reach the public transport from their homes. For instance, the residential area with the accessibility of public transport lower than 5 min by walking is categorised as high accessibility area, 6 to 10 min is medium, 11 to 15 min is low, and more than 15 min is categorised as an unreachable area by public transport.

The average walking speed for Indonesian is estimated at 5 km/hour. This summary of the walking speed of Indonesian is based on some research that was held in several locations with different gender and age. For instance, Ananda et. al., (2022) states the average walking speed for 170 male and female students in Surabaya is 1,26 m/h (4,536 Km/h). According to Yostrizal et. al., (2018) research, the walking speed of evacuees during a simulated tsunami evacuation in Padang is 1,3 m/s (4,7 km/hours) for adults and 1,5 m/s (5,4 km/hours) for children in 1,37 km walk distance. Therefore, the average speed in this research is estimated at 5 km/hour for all Depok people.

Moving to the walking time parameter, a distance of 0,25 miles (0,4 km) is often used as an acceptable walking distance in the United States (Yong & Diez-Roux, 2013). It means that Indonesian people who walk at 5 km/hour will need a time of approximately 5 minutes for a 0,4 km distance. This is the reason behind the use of the walking zone within 5 minutes, which is considered the most comfortable walking time for the community to reach public transportation. Subsequently, the usage of 15 minutes zone is based on the compact city concept that has been implemented around the world, such as in Paris, Barcelona, New York, etc. The planning concept of this city is they can access the public area (transport, groceries, leisure, etc.) within 15 minutes by walking or cycling from their home rather than travelling throughout the city by motor vehicle. Moreover, they believe 15 minutes is the maximum travel time for people willing to reach their destination by walking.

The data for this research was collected from various sources. The prime source data is Road Network for public transport and Land Use in Depok City from Indonesia Geospatial (BIG) and Google Maps. The road network and land use will be shown as spatial maps. The function of the Road Network is to evaluate how many areas for Jitney can serve the residential area and connect them to the nearest Station. Then, the function of land use in this research is to determine which area is possible as an origin or destination. Many public service spaces in one area, such as public transport access, business area, office, and educational activity, will attract more people to travel into this area. To collect this data, the spatial layer related to the traffic activity in the Depok Municipality, such as residential areas, transportation nodes, and business activity, is plotted in the Depok maps. The secondary data consists of the number of commuter-line passengers, the number of jitneys that operate for each route, and population density from some related stakeholders, such as Indonesia Railway Company, BPS- Indonesia Bureau Statistic, and Depok Transportation Department. In this research, the method to design the GIS database is explained in the flowchart in Figure 1 below.

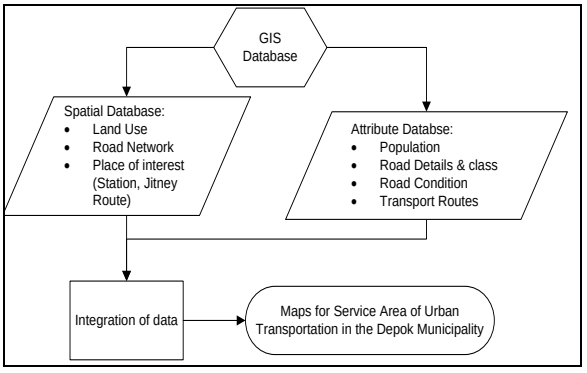

Fig. 1. GIS Database Design.

The Railway Station in Depok coordinates is collected and fed into the GIS application. After the Railway Station is placed in road network layers, the service area for each Railway Station in Depok has been created with network service analysis-based travel time and distance in a GIS application. After the road classification is determined, the relevant attributes are added. Subsequently, we can calculate how many (in km2) areas are covered by walking for 5, 10, and 15 minutes from the travel time and street view. Travel time and street view tools in QGIS help us plot the maximum barrier area for pedestrians to reach during the set period as we choose.

It calculates the paths and roads that allow pedestrians to find a solution during a particular time. The maximum area for pedestrians can travel during the exact time from the first point is called the service area. In this research, two different service area classifications are divided by the public transportation modes in Depok Municipality. Firstly, the service area for the commuter line is the area that can be covered during the time from the rail station. The service area for the commuter-line Station is focused on the rail station only. Commuter line modes only stop to carry passengers and drop passengers in the station area. However, for Jitney, the service area is along the road that is travelled because Jitney has the benefit as feeder transport modes, where they can carry and drop off passengers along their operation route. Each service area is represented by colour, such as the green area is high where people can reach public transportation in less than 5 minutes. Then, the yellow area is medium, where people should walk more to

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reach public transportation in 6 to 10 minutes, and the red area is a low accessibility area where they need a long time to access public transportation in 11 to 15 minutes. Lastly, the area where they need more walking than 15 minutes is classified as an inaccessible area for public transportation. From 20 routes of Jitney operating in Depok city, we can find the residential area covered by Jitney. Also, we can recognise the area with a high density but uncovered with jitney access. This area will be the priority area for evaluation in this research. There are two options to provide uncovered public transportation in a high-density area. Firstly, make a new route for the Jitney to this area, and secondly, extend the existing route to the uncovered area. From the transportation modelling, we can identify the possibility of new potential passengers for commuter-line with the new availability of public transportation modes.

3. Result and Discussion

a. Geographical Location of Depok Municipality

Regarding geographic position, Depok Municipality, located in West Java Province on the southern border of DKI Jakarta Province, has the following boundaries: North DKI Jakarta Province, West – Tangerang Regency, South, and East – Bogor Regency. Astronomically, the Depok location is between 6° 23' 8.1204" South Latitude and 106° 47' 39.266" East Longitude.his city has 11 administrative districts: Sawangan, Bojongsari, Pancoran Mas, Cipayung, Sukmajaya, Cilodong, Cimanggis, Tapos, Beji Subdistrict, Limo, and Cinere Subdistrict.

b. The Population of Depok Municipality

According to the annual report in 2022 from BPS- Statistics of Depok Municipality, 2.085.935 people live in the Depok area, where 1.089.295 people of the population are economically active or working, and 175.268 people are attending school. A total of 1.264.563 people are possibly doing a travel activity in the Depok area or the other area as daily commuters. The densest population is located in Cipayung, Sukmajaya, Pancoran Mas, and Beji areas (see. Figure 2). This location is connected to a commuter line station. Therefore, many commuters who travel to CBD in Jakarta or other Districts around the Depok area will choose to live in the centre of the Depok area with better transportation access to reduce travel time from their residence to their daily destination.

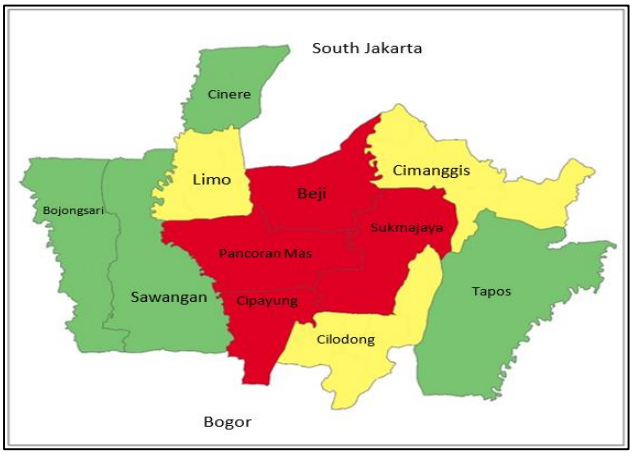

Fig. 2. Population Density in Depok Area.
Source: GIS Result from BPS Data.

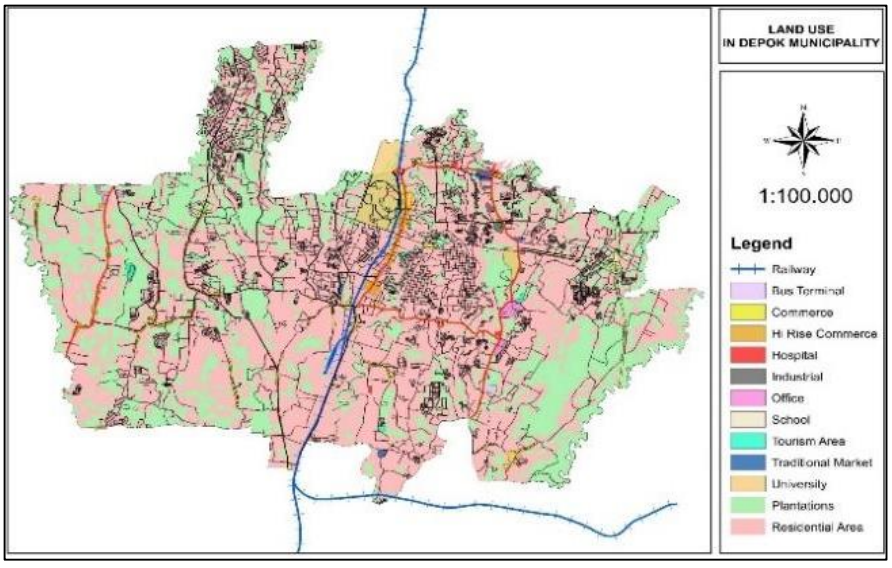

Fig. 3. Land Use in Depok Municipality.
Source: GIS Result from BIG and Bappeda Depok Data.

c. Land Use and Travel Attraction Area

Moving on to the land usage in the Depok area is mainly used for the residential area (see Figure 3). Some travel attractions are primarily placed in the Depok municipalities' central areas because many business activities are located there, such as the retail store, mall, university, tourist, hospitality, and office areas. Moreover, all railway stations in the Depok area are in the centre of the Depok area. Passengers who want to travel to the Jakarta CBD area by public transport should travel to the middle location of Depok.

d. *Rail and Road Network in Depok Area*

Figure 4 shows us the rail and road network in Depok Municipality. There are arterial roads (red line) along the west part (Jakarta-Bogor Street), central part (Margonda Raya Street), and east part of the Depok area (Bogor Raya Street). Turning to the collector road (bold black line), this kind of road classification is mostly located in the west and central Depok area. There are few collector roads in the east part of the Depok area. However, there is a Toll Road (Jagorawi Toll Rd.) in the east part of the

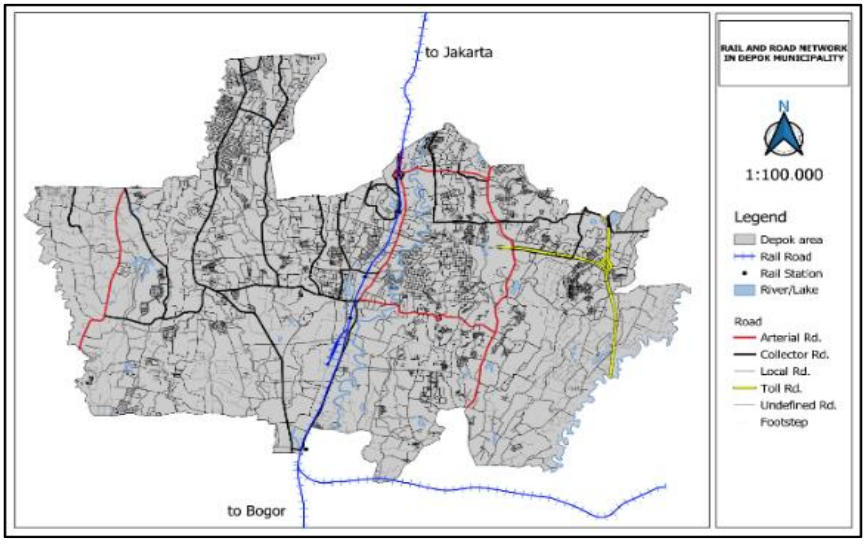

Fig. 4. Road Network Classification.
Source: GIS Result from BIG Data.

Table 1
Jitney Route Traveled Around the Commuter line Station.

No.	Station	Jitney Route	Total Route
1.	Pondok Cina	D.11	1
2.	New Depok	D.1, D.2, D.3, D.4, D.5, D.6, D.7, D.8, D.9, D.10, D.11, D.15R	12
3.	Old Depok	D.5, D.8	2
4.	Citayam	D.5, D.26	2

e. Jitney Route and availability

Most of the Jitney routes are operated on the arterial and collector road rather than a local road. Looking at the west side, people need to travel by using two different jitney routes to reach the Station. For instance, people from Bojongsari and Sawangan area should travel by D.28, D.27, D.21, and D.25 to transit to the Sawangan Terminal, then take route D.26 to the Citayam Station or D.03 to the New Depok Station. This condition also applies to people living on the Depok area's east side, such as Tapos and Cimanggis Subdistrict. They should take two jitney routes to reach the Station. For example, people from Tapos and Cimanggis should travel by D.69 or D.107, then change the line for D.06 route in Cisalak Traditional Market to reach New Depok Station. On this east side, there is D.17 route that does not integrate with the other Jitney route to reach the rail station.

f. Jitney Route Planning

According to the interview session with the Head Division of Rollingstock for Public Transport in the Transportation Department of Depok Municipality that was held on 26 April 2022, we get information about how the local government plans and evaluates the public transportation that operates in and around the Depok area. Overall, there are 2884 fleets that serve 22 different routes around the Depok area, all of which are under private ownership. Several jitney routes operate from Bogor and Tangerang Municipality.

g. Jitney Tarif

Regarding the information from the Head Division of Rollingstock for Public Transportation, there are maximum and minimum tariffs from the Ministry of Transport as central government and west java local province that should obey for all private Jitney and minibus operators in the

Depok area. The tariff is around Rp.186,- to Rp.303,- per kilometre, or the passengers are charged around Rp.2000,- for a short trip and a maximum Rp.4000,- for a long trip destination. However, this regulation that was set in 2014 is not applicable in 2022. During the rise of operational costs such as fuel price, jitney maintenance, and driver wage, many Jitney operators increase their tariffs around Rp.5000,- to Rp.10.000,- per passenger for the long trip destination and obey the standard tariff maximum regulated by the government.

h. Public transportation and its integration between rail and land public transportation based in Depok Municipality.

1) Jitney Intracity

According to the Transportation Department ofDepok Municipality, there is 20 jitney route that operates in Depok. Among the Jitney route above, there are five highest availabilities according to its total cars D.03 (272 cars), D.02 (241 cars), D.05 (214 cars), D.06 (162 cars), and D.04 (130 cars). The lowest availability is D.15, D.21, D.26, D.27, and D.28. This route is available according to the data from the Department of Transportation Depok Municipality, but only a few Jitney operators operate in this route due to the possibility to get passenger is lower than the other route.

2) Commuter Line

In December 2020, Indonesia Railway Company owned 1150 car units and will continue to add more trainsets to meet the requirements of commuters' demand increasing in the future. During 2020, the average number of Commuter line users per day reached 424 thousand passengers, and the total number of passengers in that year was 155 million people.

There are seven routes around the Jabodetabek area: Bogor/Depok – Jakarta Kota, Bogor/Depok Jatinegara, Tanggerang – Duri, Rangkas Bitung – Tanah Abang, Cikarang – Jakarta Kota, and Tj. Priok - Jakarta Kota, and Nambo – Jatinegara. Depok Route has the highest total daily trip than the other city in the Jabodetabek area, with 181 routes per day (consisting of 130 trips for Bogor/Depok to Jakarta Kota and 51 trips for Bogor/Depok to Jatinegara).

3) Integration of Public Area

This research found that in the Depok area, there is no integration between Jitney and the Commuter line from the fare, schedule, institutional, and information integration as a public transport in Depok municipality. Jitney and rail station is just integrated into its network, where some Depok jitney routes stop around the Commuter line station area. Jitney and rail station is just integrated into its network, where some Depok jitney routes stop around the Commuter line station area.

According to the GIS result, from 20 Jitney routes, 13 jitney routes are integrated with Commuter line Station (see the Table 1). Also, we can see from Figure 5 below about the travel time contours for Jitney and Rail Station in Depok Municipality, where commuters can reach the Commuter line Station from the Jitney route in less than 5 min. Therefore, Jitney's operational route is well-integrated with Commuter-line modes based on its route network.

i. Service area of public transportation in Depok Municipality by using the GIS application.

1) The Service area for Jitney

From the 200,3 Km2 of Depok Municipality, 66,2% of the area (132,6 Km2) is covered by Jitney. The middle area in Depok is well integrated between Jitney and Commuter-line Station, such as in Sukmajaya, Pancoran mas, Cipayung, and Beji. Most residents in this area can reach Commuter-line Station in Depok by using one jitney route. The jitney route for D.01, D.02, D.03, D.04, D.06, D.08, D.10, D.07, D.11, D.15R, D.21, and D.26 operates around the middle area of Depok. However, people need extra effort by taking at least two or three jitney routes to reach the Commuter-line Station from the West (Bojongsari and Sawangan) and East (Tapos) areas.

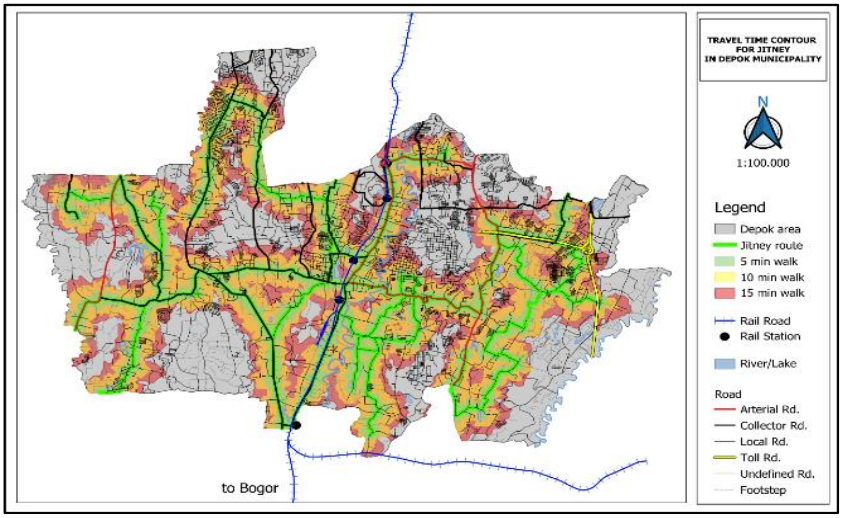

Fig. 5. Travel Time Contour for Jitney in the Depok Municipality.
Source: GIS Result from BIG and Depok Transportation Department Data.

Table 2
Total Travel time Contour in Depok Area (each Subdistrict).

No.	Sub District Area	Area in Km2			Total
		High accessibility (5 min)	Med accessibility (10 min)	Low accessibility (15 min)	
1	Tapos	7,903803	8,219338	5,139327	21,262468
2	Pancoranmas	6,603912	6,140364	3,234547	15,978823
3	Sawangan	6,033917	5,64192	3,152144	14,827981
4	Cilodong	3,903692	4,470159	3,603856	11,977707
5	Beji	4,407272	3,926972	3,554145	11,888389
6	Sukmajaya	4,983926	3,694077	2,771738	11,449741
7	Cimanggis	3,553752	3,612613	3,623757	10,790122
8	Bojongsari	3,286329	4,012512	3,478158	10,776999
9	Cipayung	3,818972	3,786104	2,438361	10,043437
10	Limo	2,30552	2,669604	2,541052	7,516176
11	Cinere	2,164255	2,112759	1,629737	5,906751
Total in Depok Municipality		**48,96535**	**48,28642**	**35,16682**	**132,618594**

Figure 5 shows a 48,96 Km2 area that can be reached in less than 5 min by walking. This green area in this figure is called high accessibility for jitney passengers because they need less time and distance to reach the jitney route from their residence. After that, the medium accessibility or 10 min walk (yellow area) has 48,28 Km^2 of the total area in Depok. Lastly, for low accessibility areas for 15 min walk (red area), it reaches 35,16 Km^2. For the total travel time contour area, each Subdistrict in Depok Municipality can be shown in table 2 below. This table shows the area near the road mostly has better accessibility for pedestrians than the area far from the road.

2) The Service area for Jitney

As we can see from Figure 6, jitneys connect passengers from the west and east area to the New Depok (D.03 and D.06) and Citayam Station (D.26). People from Bojongsari, Sawangan, and Tapos have fewer options to travel to the Pondok Cina or Old Depok Stations because the jitney route from these areas serves only to New Depok or Citayam Station. Therefore, as the total graph of daily commuter-line passengers per day, as Figure 10 shows, New Depok and Citayam Station have higher occupancy of people travelling from this Station than Pondok Cina and Old Depok Station. It is caused this Station mainly serves not only passengers from the central area but also the west and east area of Depok Municipality.

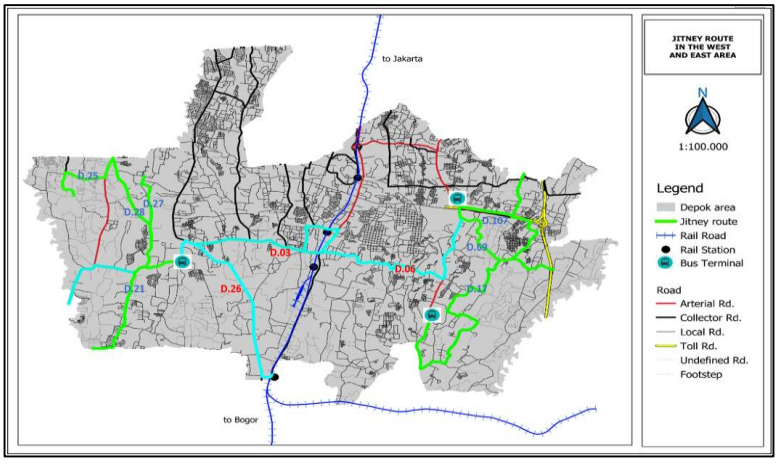

Fig. 6. Jitney Route for Passengers from Station in Depok Municipality.
Source: GIS Result from BIG and Depok Transportation Department Data.

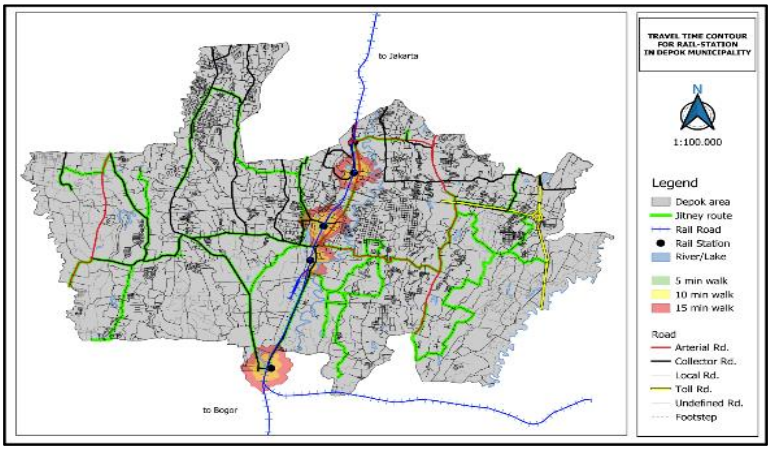

Fig. 7. Travel Time Contour for Rail-West and East area of Depok.
Source: GIS Result from BIG and Depok Transportation Department Data.

3) Service Area for Commuter Line Station

Four stations are located in the Depok Municipality area: Pondok Cina, New Depok, Old Depok, and Citayam Station. In this research, we divided the travel time into 5, 10, and 15 min to reach the Station by walking. According to Figure 5 above, the jitney route network is well integrated with four rail stations in Depok because the travellers from the Station can reach the jitney route in around 5 min coverage area. Regarding figure 7, there are some differences between the travel time contour for 5, 10, and 15 min between Old Depok Station and the other. Station in Depok Municipality. Old Depok Station has the smallest travel time contour among the other Station.

Table 3
Travel Time Area in Depok Commuter-line Station.

No.	Station	Travel Time Area (in meter^2)		
		5 min	10 min	15 min
1.	Pondok cina	114.994	741.875	2.074.947
2.	New depok	185.013	1.013.992	2.473.655
3.	Old depok	85.017	454.950	1.035.012
4.	Citayam	165.000	1.085.006	2.794.353

4) Availability of Commuter Line

The Commuter line Jabodetabek has a total of eight to twelve trainset per train depending on the passengers' demand. The maximum trainset will be operated mostly in the peak hour. However, on the weekend or off-peak hours, the train uses a minimum trainset. The Commuter line headway in peak hours from 5.00 to 10.00 and 16.00 to 20.00 approximately arrived every 3 to 6 minutes. However, in the off-peak time from 10.00 to 16.00 and 20.00 to 23.00, the train will through the Station every 7 to 15 minutes.

j. Jitney The Residential Area Not Covered by Public Transport in Depok Municipality

The residential area uncovered by public transport can be determined by evaluating the travel time contour for Jitney and Rail-station in Depok Municipality. Figure 8 explains that some residential areas should travel to the Jitney route or rail station for more than 15 min by walking from their house (pink colour). This residential area is highly likely for commuters to choose private transportation, such as motorcycles or cars, to support their daily travel activity. From 200,3 Km^2 of Depok Municipality area, there is 141,0 Km2 area covered by a rail-station and jitney route. Then, from the 132,4 Km^2 residential area, 92,36 Km2 area is covered, and 40,04 Km^2 is uncovered by public transport.

As we can see from Figure 9 below, there are some residential areas that do not have access to jitney service. There are some reasons for this problem. Firstly, the residential area is far from the Arterial and Collector Road. Some local roads cannot be accessed by Jitney because the local road in the Depok area is a single-track road. Some areas with a single-track road are hard to access by car or Jitney, such as in point area number 1 in Figure 9. Adding public transport in this area will cause congestion, and it will cause a longer travel time to reach the Commuter-line Station. Some residential areas located far from the jitney service area tend to use a park-and-ride scheme. They travel from their home by motorcycle, park it around the station area, and reach their office or school by Commuter-line station.

Secondly, there is a low desire for people to travel by Commuter-line because their residential area is far from the middle area of Depok to access Commuter-line modes. For instance, residential areas 2 and 3 in the west and east area of Depok Municipality tend to drive by bus, car, or motorcycle because they have better access to reach toll and arterial roads. Therefore, this residential area where the demand for jitneys is low is not too attractive for jitney operators.

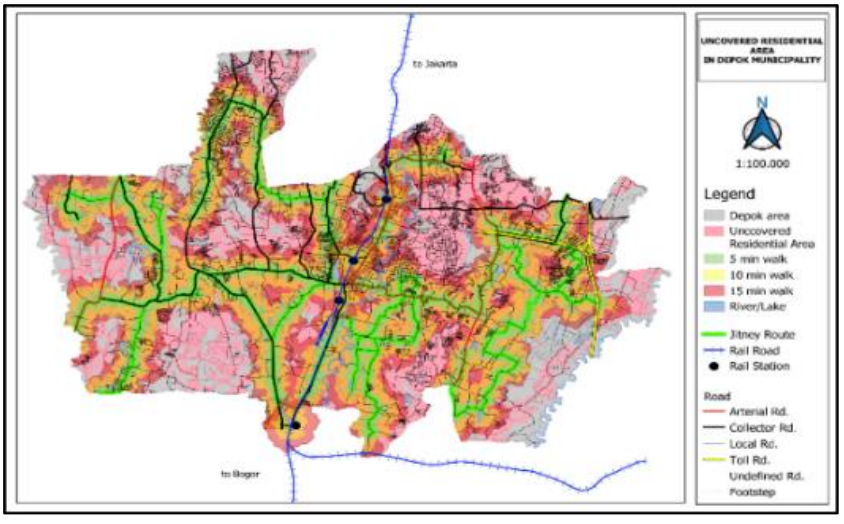

Fig. 8. Uncovered Residential Area in Depok Municipality.
Source: GIS Result from BIG Data.

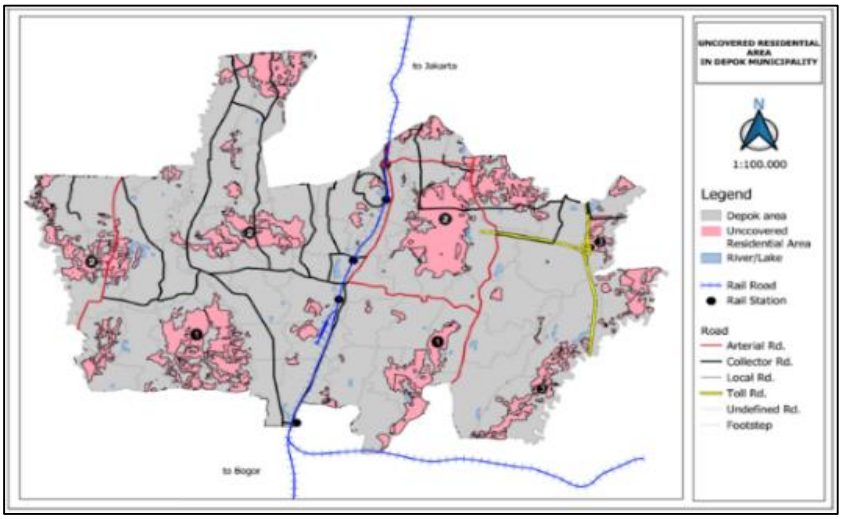

Fig. 9. Uncovered Residential Area from Jitney and Rail Station Service.
Source: GIS Result from BIG.

k. *The service area and the occupancy of the passenger in the public Transportation in Depok Municipality*

Citayam and New Depok Station has the highest occupancy for average daily passenger at 19.015 people/day for Citayam Station and average daily passenger at 18.566 people/day for New Depok Station. Then Old Depok Station always got a lower average daily passenger occupancy than Citayam and New Depok Station for approximately 13.052 people/day. In the last position, the average daily passenger in Pondok Cina Station is 10.577 people/day from January to October 2022. All the stations in the Depok Area have a sharp fall in daily occupancy during the weekend or National Holidays.

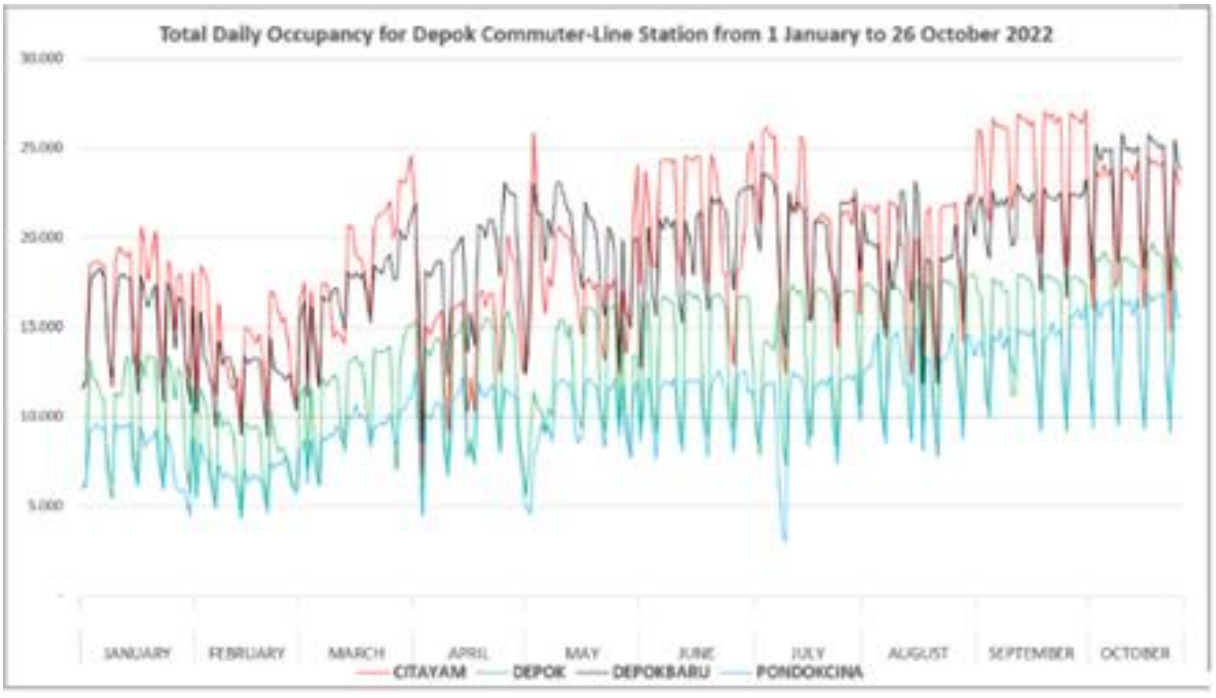

Fig. 10. Daily Passenger of Commuter-Line in Depok from 01 January to 26 October 2022.
Source : PT. KCI Jabodetabek.

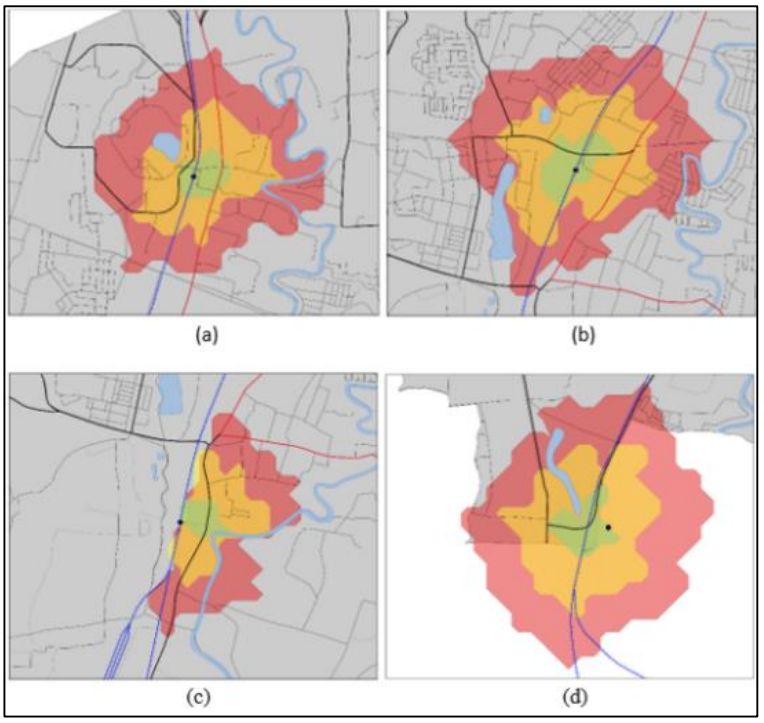

Fig. 11. Travel Time Contour for 5, 10, and 15 min walks in:
(a) Pondok Cina Station.
(b) New Depok Station.
(c) Old Depok Station.
(d) Citayam Station.
Source: GIS Result from Indonesia Geospatial (BIG) Data.

According to Table 3, the Old Depok Station has the lowest service area among the four stations in Depok. If we compare the total daily occupancy of Depok Station with the service area for the Station. It shows the relation between daily occupancy and the service area of the Station, where Old Depok station is always lower than the occupancy of Citayam and New Depok Station. However, the Pondok Cina Station has the lowest occupancy than the otherStation, although it has a bigger service area due to the configuration of land use around Pondok Cina different from other stations. Citayam, New Depok, and Old Depok Stations are located around some residential areas, but Pondok Cina Station is University and Public School area.

Turning to the data about the total daily occupancy of Jitney is hard to find due to the Jitney in Depok area is operated by private ownership, which there are no information integration among all Jitney operator. Moreover, the payment system is based on the physical cash, where counting the daily passengers for Jitney is harder than the other public transportation with the payment by computational system (Tap Cash, Credit Card, Debit Card, etc.). Most of these payment transaction will be inputted in the system and count it as the total passengers.

l. The best transportation route model to increase accessibility and widen the service area for passengers.

4) Increasing the Accessibility for Old Depok Station

There is a relationship between accessibility and total ridership. Let's compare Figures 11 (b) and (c) for the travel time contour for New Depok and Old Depok Stations to the daily occupancy of the passenger in Figure 10. There is a correlation that a wider travel time contour or service area for commuter line stations can cause higher ridership. Old Depok and New Depok

Station are located in similar zone conditions in the strategic business area of Depok Municipality. However, Old Depok Station has around 5000 passengers, lower than New Depok Station per day in 2022. Improving the service area for Old Depok Station can be one of the other solutions to gain the daily passenger. For instance, applying the entrance and exit gate not only in the east area but also in the west area, like the other stations in New Depok, Pondok Cina, and Citayam Station, will raise the service area in this Station. We simulate the actual condition for Old Depok Station with just one gate access in the east area and the other condition with an additional gate in both the west and east areas of the Station. The simulation results are shown in Figures 12 (a) and (b) below.

Fig. 12. Travel Time Contour.
(a) Existing Condition.
(b) Estimation with Addition Gate on the West Side of the Depok Station.
Source: GIS Result from Indonesia Geospatial (BIG) Data.

Table 4
Travel Time Contour Area in Old Depok Station (Existing Condition and With Road on the West Side).

No.	Old Depok Station	Travel Time Contour Area (in meter^2)		
		5 min	10 min	15 min
1.	Existing Condition	85.017	454.950	1.035.012
2.	Addition Gate Access on the West Side	206.807	932.298	2.331.724

2) Duplicate Coverage Area Between New Depok and Old Depok Station

According to the figure 13, there is a coverage gap or duplicate coverage area in 15 min travel time by walking (red area) for 8881 m^2, with the distance between these stations is 1,7 Km. This problem causes the inefficiency of commuter line operation by increasing travel time for passengers and increasing the operation cost for public transport. Furthermore, a short gap between the Station is less useful for the passenger because it will minimize the ridership and service area of the Station (Walker, 2012, p.63). Comparing the distance for all the Depok Stations shows that Old Depok and New Depok Stations have a closer gap than the other Station (see Table 5).

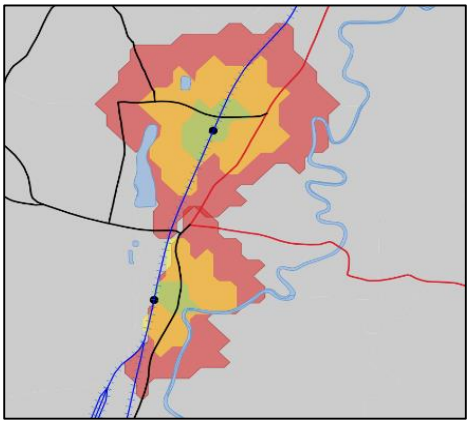

Fig. 13. Travel Time Contour for New Depok and Old Depok Station.
Source: GIS Result from BIG Data.

Table 5
Depok Station Distance.

No.	Station	Distance
1.	Pondok Cina to New Depok	2,570 Km
2.	New Depok to Old Depok	1,743 Km
3.	Old Depok to Citayam	5,084 Km

4. Conclusions and Recommendations

Four as stated in the beginning, geospatial maps can give a broad view to evaluate our transportation system. Determining the demand of passengers that live around the Depok municipality and designing the best transportation route model to increase accessibility by integrating the rail station and Jitney service area can be achieved by using the GIS application. There is some conclusion that can find from this study. Looking at the rail station first, a higher travel time contour for pedestrians increases the occupancy of public transport commuters. It is related to the findings between the Depok Station and the other stations in Depok Municipality (Point 3.k. Service Area and the occupancy of the Passenger in the Public Transportation). A minimum entrance and exit gate for Old Depok station cause a lower daily occupancy of commuter passengers than in the New Depok station with exact locations in the Depok Municipality business area. Another important finding was that a duplicate coverage area between Old Depok and New Depok Station could cause slower commuter line operation and minimise the station's service area. The duplicate area occurred because there was a short gap between the stopping points at these two stations.

Moving on to the travel time contour for the Jitney. High accessibility area, where the area can reach the road travelled by Jitney for less than 5 min, is broader than medium accessibility (10 min by walk) and low accessibility (15 min by walking). It shows that the area near the main road has better accessibility for pedestrians than the area far from the main road. (Point 3.i. Service area of public transportation in Depok Municipality by using the GIS application). Looking at the availability of Jitney, the middle

Area of Depok Municipality (Pancoran Mas, Sukmajaya, Beji, and Cipayung Sub District) has better integration with Commuter-line Station. It is because most of the Jitney operates in the Depok middle area for 1463 cars, then in the west area (Bojongsari, Sawangan, Limo) for 276 cars, and the east area (Tapos, Cimanggis, Cilodong) for 361 cars. Also, the middle area has better accessibility because it covers most of the roads in the middle area of Depok Municipality (Point 3.h. and 3.i). Furthermore, people from the west and east area should travel by using more than one jitney route to reach the rail station. There are low Jitney availability for route D.15R, D.17, D.21, D.25, D.26, D.27, and D.28, mostly located in the west and east of Depok Municipality (See figure 6). Therefore, the local government should increase the jitney availability in that area to increase the service area of public transport. For instance, the subsidies or incentives from the government to the jitney operators can attract jitney operators to operate at the low demand of passengers.

In this study, we determine that there are different travel time characteristics among four commuter line stations in the Depok Municipality area. The Citayam and New Depok Stations have wider access for pedestrians which these two stations have a more extensive service area than Old Depok Station, whereas Old Depok Station has restricted access to the west area of this station. Moreover, from the occupancy data of daily passengers for each station, it can be shown that the higher the station's service area, the occupancy of the daily passenger also increases. We determine that the availability of jitney follows the demand of the population of passengers. The business area in Pancoran Mas, Sukmajaya, Beji, and Cipayung Sub- district has a higher availability of jitney than the west and east areas with lower population density. One interesting finding is there are no travel analyses from the Transportation Department of Depok Municipality or local public transport organizations as private jitney operators. However, the jitney operator can determine the high-demand area of the jitney and place their jitney modes in the route with a high passenger occupancy. It could be shown that the availability of jitney, which operates in the middle area, outweighs the other location in Depok Municipality.

Moving on to the uncovered residential area from public transport access in Depok Municipality. A possible explanation for this problem might be that some residential areas are located far from the main road, primarily arterial and collector roads, where jitney operates on this road. There is some residential area using a local road that has a narrow width, such as a single-track road, making this area harder to access by jitney. The ineffective jitney route planning is the other reason that there are some uncovered residential areas from public transport access. According to the interview with the Transportation Department in Depok Municipality representatives, most of the jitney route establishment is based on a bottom-up scheme. The Organda, as local jitney owner representatives, convey their aspiration for their jitney route to the local government as a public transportation planner. The local jitney organisation will focus more on the profitable route with much more access around the dense area rather than on the area that still has no access to public transportation. It can be seen from the jitney route in Depok Municipality, where the central Depok area has the densest population travelled by jitney more than the other area. Among 2100 total jitneys in Depok Municipality, 69,7% of them travelled to the middle area. This causes overlapping from one with another jitney route.

In conclusion, there are many travel options nowadays in Depok Area. People can travel by using private cars, motorcycles, or online-based transportation, such as online motorcycles and cars. However, to serve 1,2 million daily commuters from Depok to the Jakarta CBD area, it is impossible to depend on road-based transportation, mostly occupied by private transportation modes. Better integration between public modes from road-based and rail-based is essential to reduce the severe congestion problem. For road-based transportation modes in the Depok area, jitney serves two third (66,2%) of the Depok Municipality area. Then, from the total daily commuters in Depok, only 7% of the daily commuters use commuter line modes. With the low percentage of rail commuters in the Depok area, further research should be undertaken to investigate what aspect can increase the demand for rail-based public transportation. It is not only from the accessibility of the service area from their residence to the station but also from the other aspect such as the frequency, travel time, comfortability, cost, reliability, customer service, service information, safety, etc.

The suggestion that can be stated in this study is focused on the jitney route and rail station services for some stakeholders, such as Jitney Operator, Commuter-line Operator, and Depok Transportation Department as a local public transport planner in Depok Municipality. Firstly, for the jitney route, we suggested wider the service area by adding more routes on the west and east side of the Depok area, including Bojongsari and Sawangan in the West area and Cimanggis and Tapos in the East area. Then, for the following new jitney route, the local transport department shouldconsider covering some residential areas that were uncovered by jitney services. Also, increasing the availability of jitney operations in this area above is important because nearly 70% of the jitney operates and is concentrated in the central area.

Secondly, for the rail station service area, the widened service area for pedestrian access in the west area of Old Depok Station has potentially increased the number of commuter-line passengers around this station. Then, the duplicate coverage area between the Old and New Depok Stations due to the short range for both stations can reduce the service area for commuting people to access the station. It could be better to place the Old Depok Station to the south to cover the Citayam Station area, where the gaps between these stations are nearly three times as far as the distance

between Old and New Depok Station. The Distance fromNew Depok to Old Depok Station is 1,74 Km, while the Old Depok Station to Citayam Station is around 5,08 Km.

Thirdly, the jitney operator and the Local Transportation Department should collaborate to determine the new jitney route to achieve an effective jitney route not only based on the profitability for the operators but also increase the availability and service area around the inaccessible residential area from jitney in Depok. In this research, the usage of a GIS application to evaluate the public transportation route in the Depok area can be a way to achieve better integration between road-based and rail-based public transportation. Lastly, from the road infrastructure in Depok, increasing some local roads from single-track roads to two-lane roads can increase the accessibility of jitneys to serve their passengers from inaccessible residential areas to public transportation.

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