Catchment Area of Park-and-Ride and Kiss-and-Ride nearby Citayam and Bojonggede Railway Station

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Abstract. Rail-based transportation, namely trains, has an important role for communities in sub-urban areas. By using the train, communities no longer need to use their vehicles. They can change modes with two choice of ways to get to the station, park their personal vehicle or by using shuttle transportation. The concepts of the two-ways is a form of implementation of park-and-ride and kiss-and-ride. This study aims to identify the reasons why KRL users choose park-and-ride or kiss-and-ride facilities and the user spatial patterns of these facilities. The analysis uses the E2-SFCA (Enhanced 2-Step Floating Catchment Area) method by calculating the distance and ratio of station users and then produces an accessibility value. The results of the analysis that have been carried out indicate that the majority of park-and-ride users are spread out in zone 2 and kiss-and-ride users are spread out in zone 1. The catchment area from both stations are predominantly from areas with local road network characteristics. This road network has a high density but limited vehicle speed. The cost and origin of the distance from the place of residence affect the difference in the catchment area of the KRL station.

1. Introduction

The park-and-ride concept is a parking location for commuters who go using private vehicles and then want to continue their journey by using public transportation [1]. This park-and-ride concept can be a concept that is quite optimal implemented around the station location or bus terminus in commuter areas, especially Jabodetabek, to facilitate mobility and change modes from private vehicles to public transportation [2]. Kiss-and-ride is a concept or method of transportation changing modes by shuttle passengers from different modes and not parking vehicles around terminals or transit points [3]. Besides the two theory, park-and-ride can also be referred to as a facility of land provided by the manager to accommodate parking vehicles with a long duration and kiss-and-ride also be referred to as a facility of land provided drop-off and pick-up point passengers by taxi, parking motorcycle, taxi-bike, shuttle, and parking vehicle with short duration [4]. Depok City and Bogor Regency are the metropolitan areas in West Java Province, which have functional relationships and form a system based on Law of the Republic of Indonesia No. 26 of 2007 concerning Spatial Planning. The DKI Jakarta provincial government determined the determination of this metropolitan area in 1977. Jakarta city is densely packed to accommodate all government, economic, and industrial activities. Citayam and Bojonggede are sub-urban areas shown by the development of the spillover effect from DKI Jakarta, which is the spread from a modern city to sub-urban areas with low building density. This growth occurs to have a place to live in an area with a reasonably cheap land price for commuters [5]. These two methods are an
option for the community, especially KRL users when they want to trip, and the purpose is to use trains that are close to their residence. KRL users who want to go to their home stations have their trip background and choose whether they want to park-and-ride or kiss-and-ride. This study aims to identify why commuter line users choose park-and-ride or kiss-and-ride facilities and the user spatial patterns of these facilities. This goal is, motivated by questions about the behavioral factors in using park-and-ride or kiss-and-ride as an intermediary to get to the station and spatialize how far the catchment area is from each station by calculating the distance between residences. KRL users with the station of their choice.

2. Method
2.1. Study area
Citayam Station is the southernmost station in Depok City. This station is one of the stops for electric circuit trains or commuter lines that reach sub-urban communities living around Bojong Pondok Terong District and the sub-urban of Bogor Regency. The distance between the next station, namely Depok Station and Bojonggede Station, is relatively far, about ± 5 KM. In absolute terms, Citayam Station is located at 6°26′56.09″ south latitude and 106°48′8.50″ east longitude (Figure 1). Two collector roads flank Citayam Station are on the west side (Jl. Raya Pitara) and east (Jl. Raya Citayam).

![Figure 1. Study research area.](image)

2.2. Materials
In collecting data, field observations need to be carried out to see the place and situation directly and conduct online interviews using questionnaires to KRL users who routinely use the train at Citayam and Bojonggede stations and collect tabular and spatial data from the Depok City and Bogor District government. It shows in Table 1.

| Data                          | Source                       |
|-------------------------------|------------------------------|
| Administrative map of Depok City and Bogor District 1: 25000 | PUPR Office                  |
| Network Road Map of Depok City and Bogor District 1:25000 | PUPR Office                  |
| Commuter Line Schedule        | PT. KAI Website              |
| Public Transport Route        | West Java Transportation Office |
2.3. Methods
In this study, the case is an infinite population, which is a population whose exact number is never known. This term is used for a population whose daily numbers are uncertain and will always change [6]. The sampling technique uses a simple random sampling method, which means that every individual in a population has the same opportunity to be used as a sample [7]. For passenger data per quarter in 2021, as many as 31,986,000 based on data from Badan Pusat Statistik (BPS) Indonesia. In determining the number of respondents, the Slovin formula [8] is used:

\[ n = \frac{N}{1 + Ne^2} \]  

(1)

\( n \) = Number of Samples  
\( N \) = Total Population  
\( E \) = fault tolerance 10%

The number of passengers in the quarter in 2021 is 31,986,000, so the formula for the number of samples is obtained as follows:

\[ n = \frac{31,986,000}{1 + 31.986,000 (0.1)^2} = 99,9992542 \sim 100 \]  

(2)

Classification is carried out with the following formula:

\[ Classification = \frac{\text{farthest distance–closest distance}}{3} \]  

(3)

2.4. Data analysis
In analysing the data, it was done descriptively using the E2-SFCA (Enhanced 2-Step Float Catchment Area) method. This method is one of the GIS methods to measure how far a service can reach the community in one area [9]. The E2-SFCA method requires at least three main parameters, namely accessibility, population density or density of demand, and distance. This method assumes the relationship between demands, namely the users of park-and-ride or kiss-and-ride facilities and supply are Citayam and Bojonggede train stations. Following are the steps in carrying out the E2-SFCA method:

1. Determine the farthest reach from each station based on the respondent's residence. The division of coverage is divided into three areas, with each residence will be entered into three zones.
2. Perform the weighting using the Gaussian function, which is divided into three weights into three zones; 1, 0.42, and 0.03. The weighting is done by dividing each station distance with the respondent into three zones.

\[ W_{kj} \text{ or } W_{ij} = \begin{cases} 1, & \text{if } dkj \text{ or } dij \in \text{zone 1} \\ 0.42, & \text{if } dkj \text{ or } dij \in \text{zone 2} \\ 0.03, & \text{if } dkj \text{ or } dij \in \text{zone 3} \end{cases} \]  

(4)

The respondent passenger ratio per train station is assigned the variable "j" then defined as the area with a trip zone of 30 minutes (farthest). The location of the respondent "k" is divided per each trip time zone (Dr) from location j then each is weighted location-to-population, Rj, with the following formula:

\[ R_j = \frac{s_j}{\sum_{k \in (dkj \in Dr)} p_k W_{kj}} \]  

(5)

\[ = \frac{s_j}{\sum_{k \in (dkj \in D1)} p_k W_{k1} + \sum_{k \in (dkj \in D2)} p_k W_{k2} + \sum_{k \in (dkj \in D3)} p_k W_{k3}} \]  

(6)
The previous stage is the stage of station service coverage, then for this stage, the assumption of the center of each service area is the per-respondent residence and then uses the distance that has been determined from the results of the first stage. \( A_i^f \) is considered as the formula for calculating the accessibility index per respondent. This calculation adds up all the ratios (step 3) \( (R_j) \) where the address of respondents who are within the service range of the station are separated and weighted for each distance per-zone \( (d_{ij}) \).

\[
A_i^f = \sum_{j \in (d_{ij} \in D_r)} R_j W_{ij}
\]

\( = \sum_{j \in (d_{ij} \in D_1)} R_j W_1 + \sum_{j \in (d_{ij} \in D_2)} R_j W_2 + \sum_{j \in (d_{ij} \in D_3)} R_j W_3 \)

Description:
\( R_j \) = Ratio between station and number of passenger (respondent) \( (j) \)
\( A_i^f \) = Accessibility Index Value
\( d_{kj} \) = Distance origin-destination (station)
\( W_{kj} \) = Weight Distance of each station (zona 1 = weight 1; zona 2 = weight 0.42; Weight 3 = weight 0.03)
\( W_r \) = Weight distance of each station centroid (zona 1 = weight 1; zona 2 = weight 0.42; weight 3 = weight 0.03)

3. Results and discussion

3.1. Catchment area of user P-n-R and accessibility value

Visually, figure 2 shows the accessibility assessment is calculated from the distance of the residence plot to the point of the transit station for boarding the KRL. Based on the data, park-and-ride users at Citayam Train Station are dominant in zone 2 with a range of 1.6 – 3.2 km, and for Bojonggede Train Station is in the range of 1.8 – 3.8 km from the station, which is marked by yellow colour classification. As is well known, park-and-ride users prefer to choose motorbike storage plots to officers who are already known for dealing with security issues. However, it is also undeniable that KRL users who are close to the station will also choose to go to the nearest station but must choose and look for a motorbike storage plot that is considered safe so that at a specific time if you have found a secure plot, you can rent a parking lot and get to know the officers.

![Figure 2. E2-SFCA P-n-R at Citayam and Bojonggede station.](image-url)
3.2. Catchment area of user K-n-R and accessibility value

Visually, figure 3 shows the accessibility assessment is calculated from the distance of the residence plot to the point of the transit station for boarding the KRL. Based on the data, park-and-ride users at Citayam Train Station are dominant in zone 1 with a range of 0.1 – 1.7 km, and for Bojonggede Train Station, it is in a distance radius of 0.1 – 2.3 km, which is marked by green color classification. Of course, this is related to the preference of a human being to make choices that can meet his needs in a location close to their residence. However, according to field data, most kiss-and-ride users have reasons because the number of vehicles is less or even doesn't have one, the cost is cheaper to deliver, ordering an online taxi-bike is very flexible and easy, and the location of their residence is right at the transportation stop, so they only need to pay for it, stop in front of the station, and no need to walk far nor need to bother looking for a motorbike lot.

![Figure 3. E2-SFCA K-n-R at Citayam and Bojonggede station.](image)

3.3. The linkages of catchment area with travel behaviour of P-n-R and K-n-R

3.3.1. Citayam station.

Based on the data processing of the Citayam Train Station by overlaying travel behavior variables (trip costs, trip duration, trip frequency, and trip destination), park-and-ride and kiss-and-ride users, the value of accessibility as a catchment area, and the road network is obtained by the user. Visually, figure 4 interpreted the dominant park-and-ride is in zone 2 with moderate accessibility value, which costs Rp. 5,000 – Rp. 10,000 (figure 4.a) with a trip duration of 5 – 10 minutes (figure 4.b) having a travel frequency of 4 – 6 times (figure 4.c) having a work purpose (figure 4.d). Meanwhile, kiss-and-ride users who are predominantly in zone 1 with good accessibility values need to spend as much as Rp. 10,000 (figure 4.a) with a trip duration of 5 – 10 minutes (figure 4.b) traveling 1 – 3 times and 4 – 6 times (figure 4.c) for work purpose (figure 4.d).
3.3.2 Bojonggede station.

Based on data processing by overlaying trip behaviour variables (trip costs, trip duration, trip frequency, and trip destination), park-and-ride, and kiss-and-ride users, the value of accessibility as a catchment area and road network is obtained by park-and-ride users. Figure 5 shows the dominant ride is in zone 2 with moderate accessibility costs Rp. 5,000 – Rp. 10,000 (figure 5.a) with a travel duration of >10 minutes (figure 5.b) have 4-6 times travel frequency (figure 5.c) having a work purpose (figure 5.d). Meanwhile, kiss-and-ride users who are dominant in zone 1 with good accessibility values need to spend as much as Rp. 10,000 (figure 5.a) with a trip duration of 5 – 10 minutes (figure 5.b) traveling 1 – 3 times and 4 – 6 times (figure 5.c) for work purpose (figure 5.d).
Figure 5. Area overlay map with (a) trip cost; (b) trip duration, c trip frequency, (d) trip destination.

Park-and-ride and kiss-and-ride activities are influenced by cost and distance variables based on distance buffer analysis in the behavioral aspect sub-chapter. KRL users who do park-and-ride and kiss-and-ride no longer think about the aspects of duration, frequency, and the purpose of the trip because the time can be overcome by traveling earlier. The trip frequency can be erratic due to the implementation of internal work. Network (online) and KRL are cheap and efficient transportation options, especially for community working in the DKI Jakarta area and its surroundings.

The choice of park-and-ride or kiss-and-ride in this study is an important component in respondents’ preferences. Depok City and Bogor Regency still have sub-urban areas that are the choice of residence for working people, especially in urban centers such as DKI Jakarta. In addition to cheap land prices, KRL transportation is also one of the doors to get to DKI Jakarta cheaply. However, for how to get to the station, there are indeed two choices, namely if you have a vehicle dedicated to working, you can use it, which is then deposited around the station or if you want to be efficient without the hassle of looking for a motorbike parking place to be deposited, you can choose to be delivered, order an online or conventional taxi-bike, or use public transportation that has a route close to their residence. Based on [10], the study represented KRL user that park-and-ride in Bekasi-Kranji Station there are several factor in four characteristics that influence KRL user, there are: parking characteristic (parking cost, parking duration, and parking lot convenience); socio-economic characteristic (profession); and trip characteristic (trip destination, trip duration, distance origin-station, trip mileage, trip cost, and mode transportation in transit station).

Apart from travel behavior factors, field conditions such as the road network are dominated by local secondary road classes and environmental roads. Both classes of roads can only be passed by small four-wheeled and two-wheeled vehicles. The two stations are only crossed by one class of collector road. For the Citayam train station, it intersects with Citayam Street, and for Bojonggede train station, it intersects with Bojonggede Street.
4. Conclusion

The distribution of residences for park-and-ride KRL users at the Citayam and Bojonggede train stations tends to be further away than the kiss-and-ride KRL users. The catchment area of KRL users of the two stations is predominantly from areas with local road network characteristics. This road network has a high density, but the vehicle speed is limited. The main consideration for park-and-ride actors is the ease of changing modes, while the main consideration for kiss-and-ride actors is cost. In addition, this study also explain information KRL user has no longer consideration about the distance origin-station because it can be overcome using a motorcycle through shortcut.

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