Characteristics of Population, Employment, and Paratransit Service as Factors That Influence Paratransit Ridership: The Case in Bandung City

R Syafriharti1,4*, B Kombaitan2, I P Kusumantoro3 and I Syabri2

1PhD Student of Transportation, SAPPK, Institut Teknologi Bandung, Bandung, Indonesia
2Urban and Regional Planning, SAPPK, Institut Teknologi Bandung, Bandung, Indonesia
3Transportation, SAPPK, Institut Teknologi Bandung, Bandung, Indonesia
4Urban and Regional Planning, FTIK, Universitas Komputer Indonesia, Bandung, Indonesia

*romeiza.syafriharti@email.unikom.ac.id

Abstract. Angkot is the most popular paratransit in Bandung, Indonesia. This study aims to understand the characteristics of paratransit in every sub-district in Bandung based on the description of factors that could potentially affect the paratransit ridership, namely population, number of employment, population density, employment density, road density, ratio between road length passed by angkot with total road length, number of line, ratio between number of fleet with population, and ratio between number of fleet with number of employment. The method used is descriptive analysis and the relative comparison between sub-districts to determine the 'high', 'medium', or 'low' ratings for each factor. GIS interpretation is used to determine the length of road totally and that passed by angkot. It was found that sub-districts near downtown have ‘high’ rating for some built environment factors, namely population and employment categories, but still low on other factors. Some factors that have been relatively good can be seen from more number of sub-districts with ‘medium’ or ‘high’ rating than ‘low’ are population, population density, and number of line. From the results of this study can be known what factors are necessary and can be improved for each sub-district related to angkot services in the city of Bandung.

1. Introduction

As one of the big cities in Indonesia with a population of more than two million, the city of Bandung faces the problem of population mobility, especially for low-income residents. Paratransit became the choice of Bandung residents for mobility, especially angkutan kota (angkot) [1]. The existence of paratransit still raises the debate, on the one hand provides the affordable mobility services, especially for the poor or transportation disadvantage people, but on the other hand often leads to traffic and environmental issues [2, 3]. There is another important role of paratransit, as a feeder for mass transit system [3, 4], both for Bus Rapid Transit (BRT) and Light Rail Transit (LRT). In Indonesia, angkot is a popular access and egress mode for rail users [5] as well as for buses. Of course, there is still a need...
for efforts to maximize the role of angkot while reducing the negative impacts for the urban transport system.

The study of paratransit is sufficient, both for cases in Indonesia and elsewhere. In a study summarized by Phun and Yai, there are 8 (eight) areas of study on paratransit in Asian countries: 1) operational characteristics, 2) policies and regulations, cost and benefit, and market structure; 3) paratransit as feeder services to transit system, 4) fare, 5) safety and security, 6) user perception about quality services, 7) about drivers, and 8) sustainability, social and environmental impacts [2]. However, no one has specifically examined the characteristic of factors suspected to affect paratransit ridership. Therefore, the purpose of this study is to map out the characteristics of factors that potentially affect the ridership paratransit, namely population, employment, and paratransit service networks in each sub-district. The population, employment and the network of public transit services are among the factors affecting transit ridership [6], including paratransit ridership. This study is a preliminary study to find the influence of built environment and service of public transport system on the use of public transport in Bandung, including angkot.

Paratransit in this study limited only angkutan kota (angkot). Based on the characteristic of the vehicles used, angkot is public transport for passenger with fixed route, but without fixed schedule, owned and operated by private companies or individuals, and refers to various types of cars, vans, and minibuses with a capacity of 12-16 seats [7-10].

From the results of descriptive analysis in the form of the relative comparison of characteristics of factors influencing the ridership paratransit in all sub-districts, the government obtains the description of sub-districts, which are relatively more in need of improvement of angkot services. The findings in this study show different characteristics for sub-districts located around the city center with sub-districts that are far from the city center. The rating of each factor in all sub-districts is also varied, but most are 'low'. Further studies are still needed for the improvement of angkot services. Thus, the effectiveness of public transport services Bandung city as a whole can be achieved.

2. Methods
The study area is all sub-districts in Bandung, which are 30 sub-districts (see Figure 1). The Central Business District (CBD) of Bandung is in Regol and surrounding areas. All data used is secondary data from Bandung city government agencies. As can be seen in Table 1, there are four factors that will be used to describe the characteristics of angkot as one of the most dominant paratransit in Bandung. The number of population and employment will affect trip generation and attraction [8], while the density of population and employment will affect travel behavior [9-11]. Density is one D of 5 Ds (density, diversity, design, destination accessibility, and distance to transit) which is a compactness measure. The more compact an area the more it reduces the use of private vehicles [10]. Thus, the factor of demand considered in this study is not only the number but also the density of the population and employment.

In the 5 D concept, attributes related to the road are 'design' or 'street connectivity' [9]. There are various indicators representing street connectivity, among them the availability of a road or road density network or the ratio between road length and total area [8]. Total area for this case is the total sub-district area. For the case of this study, in addition to road density, it is also necessary to consider the ratio between lengths of roads passed by angkot with road length. This factor is one that can represent accessibility to angkot service. Accessibility is another D from the built environment attribute, which is 'distance to transit' [9].

Number of line is also a factor influencing transit ridership [8]. The more number of angkot lines in a sub-district will decrease the number of vehicle shifts because there is so many lines to choice for getting to destination.

The more service frequency of public transit, the higher transit ridership [6]. The more angkot that serves a sub-district, the higher angkot frequency serves the sub-district, and it is likely that the larger ridership (figure 1).
The method used to analyze the characteristics of factors potentially affecting this ridership paratransit is descriptive qualitative with the relative comparison between factors in each sub-district. Each factor in each sub-district is rated relative, low, medium, or high. Some data obtained from government agencies must be processed first before being used as a factor to understand the characteristics of paratransit in Bandung (table 1).

Table 1. Factors.

| Factors Classification          | Annotation                                                                 |
|--------------------------------|---------------------------------------------------------------------------|
| Population and Employment      |                                                                           |
| a. Population (P)<sup>a</sup>  | Population in each sub-district                                          |
| b. Employment (E)<sup>b</sup>   | Number of 18 formal business fields in each sub-district                 |
| c. Population Density (PD)<sup>c</sup> | Ratio between population with sub-district area                        |
| d. Employment Density (ED)     | Ratio between number of employment with (sub-district area)<sup>c</sup>  |
| Road                           |                                                                           |
| e. Road Density (RD)           | Ratio between (total length of road)<sup>d</sup> with sub-district area  |
| f. Road that Passed by Angkot Index (RPAI) | Ratio between (length of road that passes by angkot)<sup>d</sup> with total length of road in each sub-district |
| Line                           |                                                                           |
| g. Number of Line (NL)<sup>e</sup> | Number of angkot line that serve in each sub-district                   |
| Fleet                          |                                                                           |
| h. Number of Fleet per 1000 Inhabitants (NFI) | Number of angkot fleet for 1000 inhabitants in each sub-district       |
| i. Number of Fleet per 1000 Employments (NFE) | Number of angkot fleet for 1000 inhabitants in each sub-district      |

Source of data:

<sup>a</sup> Kota Bandung Dalam Angka 2017, BPS
<sup>b</sup> Economic Census 2016, BPS
<sup>c</sup> Distarcepi Kota Bandung (GIS interpretation)
<sup>d</sup> Dishub Kota Bandung (GIS interpretation)
<sup>e</sup> Dishub Kota Bandung
<sup>f</sup> Dishub Kota Bandung
3. Results and Discussion

Table 2 shows the ranking of each factor that has the potential to affect angkot ridership. From Table 2 it can also be seen that none of the sub-districts have the same rating index for all factors. There are at least one or two different factors index rating. However, it can be known which factors are dominant for each sub-district. The best-rated sub-districts are Sumur Bandung, Batununggal, Bandung Wetan, and Cicendo, which are located around the CBD. While sub-districts with low ratings are Sukasari, Cidadap, Bojongloa Kidul, Bandung Kidul, Cibiru, and Mandalajati, which are on the fringe of the city, away from the CBD (table 2).

| The Name of SD          | P  | E  | PD | ED | RD | RPAI | NL | NFI | NFE |
|-------------------------|----|----|----|----|----|------|----|-----|-----|
| Bandung Kulon           | H  | M  | H  | L  | L  | M    | L  | L   | L   |
| Babakan Ciparay         | H  | H  | H  | M  | L  | L    | L  | L   | L   |
| Bojongloa Kaler         | H  | L  | H  | L  | L  | L    | L  | M   |    |
| Bojongloa Kidul         | M  | M  | M  | L  | L  | L    | L  | L   | L   |
| Astanaanyar             | M  | L  | H  | L  | L  | H    | M  | L   | H   |
| Regol                   | M  | M  | M  | L  | L  | M    | H  | M   | H   |
| Lengkong                | M  | H  | L  | L  | M  | M    | M  | M   | M   |
| Bandung Kidul           | L  | M  | M  | L  | L  | L    | L  | L   | L   |
| Buahbatu                | M  | M  | M  | L  | L  | L    | L  | L   | L   |
| Rancasari               | M  | L  | L  | L  | L  | M    | L  | L   | L   |
| Gedebage                | L  | L  | M  | L  | L  | L    | L  | L   | H   |
| Cibiru                  | L  | L  | M  | L  | L  | M    | L  | L   | L   |
| Panyileukan             | M  | L  | L  | H  | L  | L    | M  | L   | M   |
| Ujungberung             | M  | L  | H  | M  | L  | L    | L  | M   | M   |
| Cinambo                 | L  | M  | L  | H  | L  | M    | L  | M   | L   |
| Arcamanik               | M  | L  | M  | L  | H  | L    | M  | L   | M   |
| Antapani                | M  | L  | H  | L  | H  | L    | L  | M   | M   |
| Mandalajati             | M  | L  | M  | L  | M  | L    | L  | L   | L   |
| Kiarcondong             | H  | M  | H  | L  | L  | M    | L  | M   | M   |
| Batununggal             | H  | H  | H  | H  | L  | M    | L  | M   | M   |
| Sumur Bandung           | L  | H  | L  | H  | H  | H    | H  | H   | M   |
| Andir                   | M  | L  | H  | L  | M  | H    | L  | H   |     |
| Cicendo                 | M  | H  | L  | M  | H  | M    | L  | L   |     |
| Bandung Wetan           | L  | H  | L  | H  | L  | M    | H  | H   | M   |
| Cibeunying Kidul        | H  | L  | H  | L  | L  | M    | L  | M   | M   |
| Cibeunying Kaler        | M  | L  | M  | L  | M  | M    | L  | H   |     |
| Coblong                 | H  | H  | M  | L  | H  | L    | M  | L   | L   |
| Sukajadi                | H  | H  | M  | M  | L  | M    | M  | L   | L   |
| Sukasari                | M  | L  | L  | L  | L  | L    | L  | L   | L   |
| Cidadap                 | L  | L  | L  | M  | L  | L    | L  | M   | M   |
| Bandung City            | M  | M  | L  | L  | L  |     |     |     |     |

Note:
H = high
M = medium
L = low

The government needs to conduct a thorough evaluation, because there are inconsistent characteristics of factors that support the potential demand, namely the number and density of population and employment, with angkot supply factors, consisting of the total length of the road or by which the angkot, number of line, and number of fleet. Sumur Bandung and Cidadap are two examples of sub-districts with relatively similar factor ratings. Sumur Bandung is almost ‘high’ rating for all the factors while Cidadap still ‘low’ for all. Unlike Batununggal, although for population and employment factors are ‘high’ category, but some factors are still ‘low’, ie ‘road that passed by angkot' and 'the number of fleet'. The same is true of other sub-districts. Whereas the factors that fall into the category of ‘low’ is an
important factor for angkot ridership because the road that passed by angkot is a representation of distance to angkot [9, 10], while the number of fleet determines the frequency of angkot services [6].

There are sub-divisions that categories for number and density of employment are ‘high’, while the number and density of population are ‘low’. For sub-divisions with conditions such as Sumur Bandung and Bandung Wetan, trip attraction is ‘high’ in Bandung, while trip generation is ‘low’ compared to other sub-divisions. However, the mode used is not necessarily angkot. Meanwhile, Regol, which is a sub-division where downtown is a category of factors, is ‘medium’.

Sumur Bandung is the only sub-division in Bandung that has a length of road with ‘high’ category, either totally or passed by angkot. Cicendo, although the road density is ‘high’, but the length road passed by angkot is only in the ‘medium’ category. Astanaanyar different condition, with ‘low’ road density, road passed by angkot that ‘high’ become not too mean. Local roads require more angkot services connected to the bus, TMB or Damri routes, as angkot should function as feeder [4].

In the angkot service network system, the number of line is mostly for sub-divisions located around the city center, namely Sumur Bandung, Cicendo, Regol, Andir, and Bandung Wetan. Apparently, the number of line is the most appropriate factor with the number and density of population or employment in Bandung.

Sumur Bandung and Bandung Wetan are sub-divisions who have ‘low’ population but ‘high’ number of employment. With a ‘high’ number of lines and a ‘low’ population, only two of all sub-divisions have a ‘high’ category for the ratio between number of fleets and the population. Different things happen for the ratio between the number of fleet with the number of employment, just the ‘medium’ category. Some sub-divisions have a ‘low’ number of employment but the ratio between the number of fleet with the number of employment ‘high’, ie Andir, Rancasari, Gedebage, Astanaanyar, and Cibeunying Kaler. What is interesting is that although the number of line is in the ‘low’ category, Rancasari and Gedebage have a ratio between the numbers of fleet with the number of employment high because the number of fleet of each line serving both sub-divisions are quite large.

Taken as a whole, the rating of most factors is low, except population, population density, and number of line (see Figure 2). These three factors are dominant factors compared to other factors. The large number of sub-divisions with high population, both the number and the density shows that angkot and other public transport are quite likely to be developed in Bandung, as the results of previous research by Cardozo et al. [8] as well as Ewing & Cervero [9, 10]. However, for employment looks still too spread or not too compact like the population (figure 2).

![Figure 2](image-url)

**Figure 2.** Comparison percentage of each factor as a whole.

The ratio between the numbers of fleet with number of inhabitant is the lowest factor compared to other factors, because 88.33% of 30 sub-divisions have low category for this factor. Factors that also include the low category is the road length that passed by angkot, because 70% sub-divisions including low category for this factor.
4. Conclusions
Sub-districts near the city center mostly experience an imbalance between ‘high’ population and employment, but the road length and other factors that are the services of angkot are still relatively ‘low’. Sumur Bandung and Bandung Wetan, located close to the city center, are sub-districts with ‘high’ number of employment but ‘low’ population, which means trip attraction is relatively ‘high’ and vice versa trip generation is relatively ‘low’ compared to other sub-districts.

Population, population density, and number of line are factors that are relatively few among sub-districts not included in the ‘low’ category, although the dominant ones are still 'medium' level. Meanwhile, for other factors more sub-districts are categorized as 'low'. With conditions like this, the government of Bandung needs to conduct a comprehensive study to optimize the role of angkot, especially as a feeder.

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