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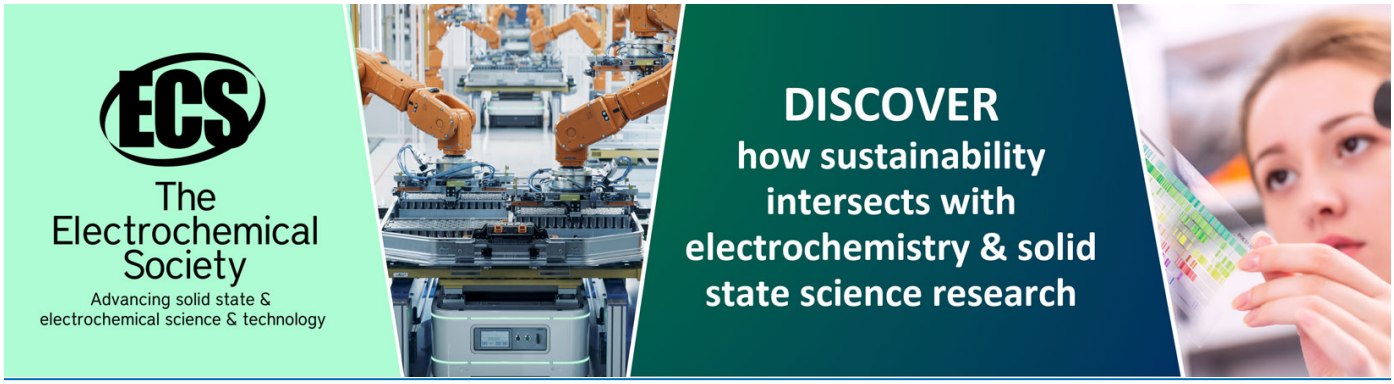

IOP Conf. Series: Materials Science and Engineering **407** (2018) 012145 doi:10.1088/1757-899X/407/1/012145

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

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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.

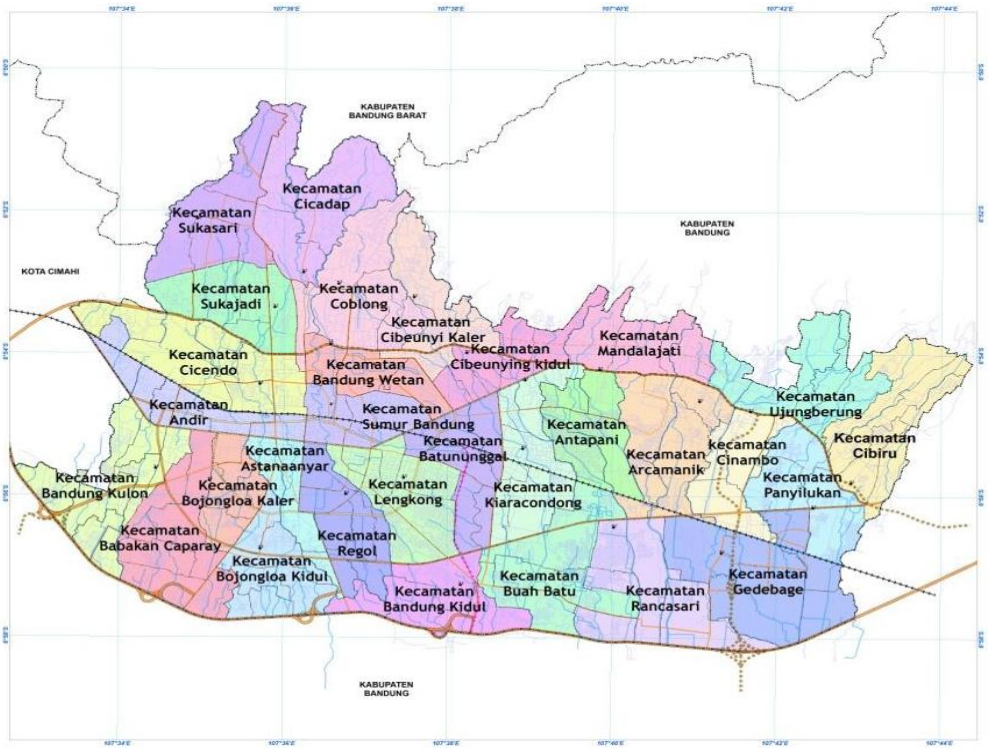
2. Methods

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).



Source: Government of Bandung City

Figure 1. Map of study area.

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)[a]	Population in each sub-district
b.	Employment (E)[b]	Number of 18 formal business fields in each sub-district
c.	Population Density (PD)[a]	Ratio between population with sub-district area
d.	Employment Density (ED)	Ratio between number of employment with (sub-district area)[a]
Road		
e.	Road Density (RD)	Ratio between (total length of road)[c] with sub-district area
f.	Road that Passed by *Angkot* Index (RPAI)	Ratio between (length of road that passes by *angkot*)[d] with total length of road in each sub-district
Line		
g.	Number of Line (NL)[e]	Number of *angkot* line that serve in each sub-district
Fleet		
h.	Number of Fleet[f] 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:
[a] Kota Bandung Dalam Angka 2017, BPS
[b] Economic Census 2016, BPS
[c] Distarcip Kota Bandung (GIS interpretation)
[d] Dishub Kota Bandung (GIS interpretation)
[e] Dishub Kota Bandung
[f] 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).

Table 2. Rating results.

The Name of SD	P	E	PD	ED	RD	RPAI	NL	NFI	NFE
Bandung Kulon	H	M	H	L	L	L	M	L	L
Babakan Ciparay	H	H	H	M	L	L	L	L	L
Bojongloa Kaler	H	L	H	L	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	M	L	M	M	M	M
Bandung Kidul	L	M	M	M	L	L	L	L	L
Buahbatu	M	M	M	M	L	L	L	L	L
Rancasari	M	L	M	L	L	L	L	L	H
Gedebage	L	L	M	L	L	L	L	L	H
Cibiru	M	L	M	L	M	L	L	L	L
Panyileukan	L	M	L	H	H	L	L	L	L
Ujungberung	M	L	H	L	M	L	L	L	M
Cinambo	L	M	L	H	H	L	L	M	L
Arcamanik	M	L	M	L	H	L	L	L	M
Antapani	M	L	H	L	H	L	L	L	M
Mandalajati	M	L	M	L	M	L	L	L	L
Kiaracondong	H	M	H	L	L	L	M	L	M
Batununggal	H	H	H	H	M	L	M	L	M
Sumur Bandung	L	H	L	H	H	H	H	H	M
Andir	M	L	H	L	L	M	H	L	H
Cicendo	M	H	L	M	H	M	H	L	L
Bandung Wetan	L	H	L	H	L	M	H	H	M
Cibeunying Kidul	H	L	H	L	L	L	M	L	M
Cibeunying Kaler	M	L	M	L	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	L	M	L	L	L	M
Bandung City			M	M	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-districts that categories for number and density of employment are 'high', while the number and density of population are 'low'. For sub-districts with conditions such as Sumur Bandung and Bandung Wetan, trip attraction is 'high' in Bandung, while trip generation is 'low' compared to other sub-districts. However, the mode used is not necessarily *angkot*. Meanwhile, Regol, which is a sub-district where downtown is a category of factors, is 'medium'.

Sumur Bandung is the only sub-district 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-districts 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-districts who have 'low' population but 'high' number of empolyment. With a 'high' number of lines and a 'low' population, only two of all sub-districts 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-districts 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-districts 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-districts 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).

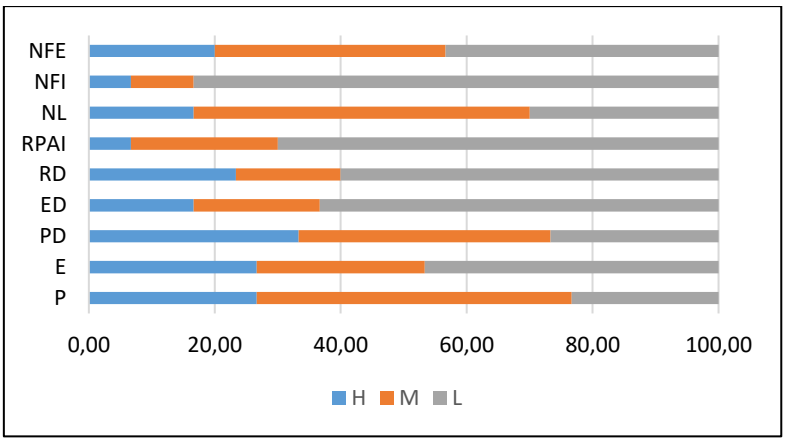


Figure 2. Comparison percentage of each factor as a whole.

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-districts have low category for this factor. Factors that also include the low category is the road length that passed by *angkot*, because 70% sub-districts 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.

Acknowledgements

This research is part of research funded by Directorate General of Higher Education, Ministry of Technology Research and Higher Education through Doctoral Dissertation Research grant. The authors are grateful for supporting data from some government agencies in Kota Bandung, ie *Dinas Perhubungan*, *Dinas Tata Ruang dan Cipta Karya*, and *Badan Pusat Statistik*. The authors are responsible for any errors.

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