Spatial Analysis of Public Transportation Accessibility for Pedestrian in Central Jakarta

FR A’rachman¹, C Setiawan¹, Warnadi¹, N Insani², SN Hijrawadi¹

¹Geography Education Department, Faculty of Social Science, Universitas Negeri Jakarta
²Geography Department, Faculty of Social Science, Universitas Negeri Malang

fauzi.ramadhoan@unj.ac.id

Abstract. Public transportation in Jakarta is one of the leading facilities which currently being improved by the local government. Transportation facilities in Jakarta are now being strived to be integrated. However, not all areas in Jakarta have access to public transportation. This study aim to show how public transportation, especially in Central Jakarta, can be reached by pedestrians. This research used a geographic information system-based approach for assessing pedestrian accessibility in metropolitan areas, focusing on access to public transportation stops and stations. This methodology attempts to provide integrated methods to urban planning and mobility planning and decision-making assistance, with the dual goals: (1) supporting sustainable and non-motorized mobility, and (2) also boosting the appeal of public transportation. There are two main steps in method. First, identify the pedestrian walking zone of urban spaces around public transportation nodes; and second, mapping the access times to create a detailed pedestrian isochrones, and calculate how residents (or how many opportunities and facilities) are well served by the public transportation system to measure accessibility levels. This study indicates that some of the main areas already have integrated public transportation facilities, but the stopping distance is quite burdensome for pedestrians to access.

Keywords: Public transportation, pedestrian, spatial analysis

1. Introduction

The shift from the use of private motorized vehicles to public transport, such as buses or trains, can increase the sustainability of the public transport system and improve environmental quality in urban areas [1]. A well-managed public transportation system will be able to increase the level of population mobility in urban areas. Therefore, a user-friendly public transportation system must consider the level of ease of accessibility to bus stops/stations and integration and connectivity to other modes of transportation [2]. One of the main goals for policymakers and regional planners is being able to prepare an efficient public transportation system in terms of accessibility, especially in metropolitan areas around the world. In the past few decades, the growing urban development is generally oriented towards private vehicles as the ownership of private cars increases. This activity has caused many people to spend more time traveling by private car. The high level of dependence on private cars will certainly affect traffic density and also the quality of life of urban communities, especially related to mobility activities.

The use of public transportation is one of the healthy activities for urban communities because it often involves walking or cycling to connect from origin to destination [3]. In this case, the ability of
policymakers to provide a high level of accessibility for a public transportation system with good connectivity can encourage active and sustainable transportation. Then from the user's point of view, an effective public transportation service is a transportation service that can provide minimal travel time, waiting time, and access to public transport stops [4]. Of course, a good transportation system requires policies from the government that are sourced from the needs of the community.

In recent years, Jakarta, as a metropolitan city in Indonesia is intensively developing an integrated intermodal public transportation system called JakLingko. The demand for a public transportation system that is friendly to residents has become a big hope for Jakarta residents [5]. There are six modes of public transportation currently in Jakarta, namely MRT (Moda Raya Terpadu / mass rapid transit), LRT (Lintas Rel Terpadu / light rail transit), Airport Railink, KAI Commuter (local train), Transjakarta (bus rapid transit system), and Mikrotrans (shared taxi)[6]. Currently, the six public transportation systems in Jakarta are being prepared to integrate into one integrated system in the transportation network and the daily lives of urban communities [7]. The high use of mobile phones allows this system to be integrated with the transportation system, especially since all mobile phones now have a global positioning system (GPS) feature. Thus convenience in public transportation in Jakarta is expected to increase.

However, the main problem with the public transportation system in Jakarta today is the existing condition, which was not designed to be integrated, or stand-alone [8]. This causes its own difficulties in modifying the stand-alone system to be combined. On the other hand, the growth of private vehicle ownership continues rises. Every day, the streets in Jakarta are filled with more than 20 million vehicles, and every year, it has been increase for about 11% of new vehicles, both motorcycles, cars, buses, and trucks[9]. This of course, forces local governments to race against time to improve public transportation services in Jakarta so that congestion on the streets can be reduced. This study aims to analyze how the distribution of public transportation stops in Central Jakarta, whether integrated or not, and map their accessibility for pedestrians.

2. Methods

This research was carried out by using spatial analysis: network analyst. Network analyst was used to see the service area of each point of the stop location of public transportation. The service area was then mapped based on the travel time criteria for pedestrians to get to that point. To carry out this analysis, it is necessary to prepare the main data, e.g., road network, and location of the stopping points of public transportation.

The network service area is an area that includes all accessible roads and is within a certain impedance. For example, a 10-minute service area for a bus stop point is all the road network that can be reached within ten minutes of reaching that bus stop. In figure 2, we can see streets and footpaths around the stop determine access. Service areas that created by Network Analysts can also help evaluate accessibility. The concentric of the service areas can show us how accessibility can change with the impedance. Once a service area is created, we can use it to identify many things are in the neighbourhood or area.

Figure 1. Service area around public transportation stops [10]
The road network in this study is used as a network analysis for pedestrians. To analyze the road network, it must be prepared in advance so that it can be input into the network dataset. First, the road network needs to be checked topology to ensure that every connected road network also has a connected vertex. After the road network topology is correct, the next step is to enter attribute data in the form of the average pedestrian speed. The average speed of a pedestrian is two meters per second or the equivalent of 7.2 kilometers per hour \([11][12][13]\). The length of the road will be calculated geometrically and then multiplied by the average pedestrian speed.

The research locations in this research are all areas within the administrative boundaries of central Jakarta (figure 3). The road network will become a path for pedestrians to reach the stopping point of public transportation. Data on the distribution of public transportation locations consists of those integrated in this area, namely Transjakarta, Mikrotrans, and KAI Commuter Station. While the bus stop is a stop point for public transportation that has not been integrated.

![Figure 2. Research location, road network, and distribution of public transportation stops](image)

**3. Results And Discussion**

3.1. Network roadmap and nodes

In this network analysis, nodes or service center points consist of 494 points, consisting of five KAI Commuter stations, 75 Mikrotrans stop points, 300 Transjakarta shelters, and 115 public bus stops. Thus, from the public transportation stops data there are 379 integrated transportation service points, equivalent to 76% of service center points, meaning that 14% of public transportation stop point facilities in Central Jakarta are not yet integrated.

3.2. Service area on all public transport stops

After conducting the spatial analysis at all public transportation service points in Central Jakarta, it was found that 41% of the area could be reached in less than five minutes on foot. Meanwhile, a total of 35% of the other areas can only be reached after walking for more than 15 minutes (Figure 4).
Compared to most other cities in Indonesia, this value is relatively good because the majority of other cities in Jakarta do not yet have a complete transportation system[14].

Areas close to public transport stops, mostly along main roads. This causes a pattern of service areas that are either elongated or polygons where in the middle of the polygon is an area that does not yet have a public transportation stop point. In addition, from the results of this analysis, it was also found that areas with less road density than other areas will have low accessibility values. Logically, this is acceptable because the number of roads can make it easier for pedestrians to choose the shortest path to the public transportation stop point.

Figure 3. Service map areas from all of the public transportation stop in Central Jakarta

3.3. Service area on integrated public transport stops

In the integrated transportation system service area, it is clear that the level of accessibility is decreasing (Figure 5). This is natural because we reduce the number of nodes as much as 14% of the total service. The pattern of service areas that were previously elongated or polygon-shaped is now more focused on certain areas. An area that has a good service area is an area in which the transportation service stop points are evenly distributed. On the other hand, areas that do not have good accessibility are areas where there are only a few public transportations stops.
Figure 4. Service map areas from the integrated public transportation stops in Central Jakarta

Data from Table 1, show that the area accessible on foot in less than five minutes fell to around 34%. Meanwhile, the service area to more than 15 minutes to public transportation points has increased to 41%. This analysis indicates that it is still very necessary to add integrated public transportation service points in Central Jakarta.

Table 1. Service area from public transportation stops in Central Jakarta

| Minutes Walking | All Public Transport Stops | Integrated Public Transport Stops |
|-----------------|---------------------------|----------------------------------|
|                 | Service Area (Ha)         | %                                | Service Area (Ha) | %     |
| 0 - 5           | 1,997.88                  | 41.19                            | 1,680.55          | 34.77 |
| 5 - 10          | 636.00                    | 13.11                            | 653.51            | 13.52 |
| 10 - 15         | 531.94                    | 10.96                            | 541.77            | 11.21 |
| 15 - 20         | 565.11                    | 11.65                            | 531.11            | 10.98 |
| 20 - 30         | 722.71                    | 14.90                            | 840.28            | 17.38 |
| > 30            | 396.39                    | 8.17                             | 585.60            | 12.11 |

Research conducted in Germany on the comfort of pedestrians when walking to public transportation is about 10 minutes. More than that, pedestrians will feel uncomfortable [15]. It also should be noted that the study was conducted in Germany. Where the climate there is much cooler than in Indonesia. Therefore, it could be that the convenience of Indonesians in walking to the location of public transportation points is less than 10 minutes. Research conducted by Koermiawan [16] mentioned that the ideal walking distance in Jakarta is 4 minutes or the equivalent of 321 meters. This can happen because it is supported by several factors, such as the tropical climate and urban heat island that occurred in Jakarta [17] will cause people to be uncomfortable lingering in outdoor activities. In addition, the poor quality of the sidewalks will make it difficult for pedestrians. In Jakarta, it is estimated that the length of the sidewalk is 2,600 km, of which only 16% have been fixed [18]. This situation is also made worse because 90% of sidewalks in Jakarta are used for illegal parking and illegal street vendors [19].
4. Conclusion

This study objectively uses GIS techniques to measure the level of accessibility of public transportation in central Jakarta. From the analysis, it is found that the optimal integrated public transportation service area only serves 35% area on the Central Jakarta. The number of public transportation stop points still needs to be added. Especially considering the tropical climate conditions and the uneven quality of sidewalks that are good for pedestrians will certainly hinder public interest in using public transportation, this will be exacerbated if the time it takes to walk to the bus stop is long enough. This study still has several limitations, for example the absence of walkable and impassable areas for pedestrians, also the condition of the sidewalks on each road segment is considered the same. Further research in the future is expected to be very good if it can include these variables in the study.

5. Acknowledgments

The author would like to express his deepest gratitude to the research team who have worked hard to complete this paper. In addition, this research can be carried out because of research funding assistance from the DIPA BLU fund, Universitas Negeri Jakarta with number 299/UN39/KU.00.01/2021. Researchers also thank the blind reviewers who have provided valuable input for the improvement of this paper.

References

[1] W. Elias and Y. Shiftan, “The influence of individual’s risk perception and attitudes on travel behavior,” Transp. Res. Part A Policy Pract., vol. 46, no. 8, pp. 1241–1251, 2012.
[2] Y.-H. Cheng and S.-Y. Chen, “Perceived accessibility, mobility, and connectivity of public transportation systems,” Transp. Res. Part A Policy Pract., vol. 77, pp. 386–403, 2015.
[3] E. Taniguchi, T. F. Fwa, and R. G. Thompson, Urban transportation and logistics: Health, safety, and security concerns. CRC Press, 2013.
[4] A. Ceder, Y. Le Net, and C. Coriat, “Measuring public transport connectivity performance applied in Auckland, New Zealand,” Transp. Res. Rec., vol. 2111, no. 1, pp. 139–147, 2009.
[5] E. Rasyid, “Sistem Transportasi yang Bersahabat dan Bermartabat di Wilayah DKI Jakarta,” 2020.
[6] PT Jaklingko Indonesia, “Jaklingko - Main page,” 2021. [Online]. Available: https://www.jaklingkoindonesia.co.id/id.
[7] PT Jaklingko Indonesia, “Jaklingko - about us,” 2021. [Online]. Available: https://www.jaklingkoindonesia.co.id/id/tentang-kami.
[8] R. Martinez and I. N. Masron, “Jakarta: A city of cities,” Cities, vol. 106, p. 102868, 2020.
[9] Badan Pusat Statistik Provinsi DKI Jakarta, “Provinsi DKI Jakarta Dalam Angka 2021,” 2021. [Online]. Available: https://jakarta.bps.go.id/publication/2021/02/26/bb7fa6dd5e90b534e3fa6984/provinsi-dki-jakarta-dalam-angka-2021.html.
[10] A. Molster and S. Schuit, “Voetsporen rond het station,” in Het Nationaal Verkeerskunde Congres, Netherlands, 2013.
[11] R. C. Browning, E. A. Baker, J. A. Herron, and R. Kram, “Effects of obesity and sex on the energetic cost and preferred speed of walking,” J. Appl. Physiol., vol. 100, no. 2, pp. 390–398, 2000.
[12] B. J. Mohler, W. B. Thompson, S. H. Creem-Regehr, H. L. Pick, and W. H. Warren, “Visual flow influences gait transition speed and preferred walking speed,” Exp. Brain Res., vol. 181, no. 2, pp. 221–228, 2007.
[13] R. V Levine and A. Norenzayan, “The Pace of Life in 31 Countries,” J. Cross. Cult. Psychol., vol. 30, no. 2, pp. 178–205, Mar. 1999.
[14] kemenperin.go.id, “Pemerintah Diminta Fokus ke Transportasi Umum,” 2013. [Online]. Available: https://kemenperin.go.id/artikel/7941/Pemerintah-Diminta-Fokus-ke-Transportasi-Umum. [Accessed: 19-Dec-2021].

[15] R. I. Sarker, M. Mailer, and S. K. Sikder, “Walking to a public transport station: empirical evidence on willingness and acceptance in Munich, Germany,” Smart Sustain. Built Environ., 2019.

[16] M. D. Koerniawan and W. Gao, “Investigation and evaluation of thermal comfort and walking comfort in hot-humid climate case study: The open spaces of Mega Kuningan-Superblock in Jakarta,” Int. J. Build. Urban, Inter. Landsc. Technol., vol. 6, pp. 53–72, 2015.

[17] S. B. Rushayati and R. Hermawan, “Characteristics of urban heat island condition in DKI Jakarta,” in Forum Geografi, 2013, vol. 27, no. 2, pp. 111–118.

[18] N. Sari, “Pemprov DKI: Baru 16 Persen Trotoar di Jakarta yang Ditata,” Kompas.com, 2019. [Online]. Available: https://megapolitan.kompas.com/read/2019/10/21/20183271/pemprov-dki-baru-16-persen-trotoar-di-jakarta-yang-ditata.

[19] I. Hamdi, “Trotoar di Jakarta Hampir 90 Persen Dipakai Parkir Liar dan PKL,” Tempo.co, 2021. [Online]. Available: https://metro=tempo.co/read/1437691/trotoar-di-jakarta-hampir-90-persen-dipakai-parkir-liar-dan-pkl.