

# Public transportation accessibility: towards sustainable transit oriented development (Case study: Depok Baru Station – Jakarta, Indonesia)

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**Abstract.** Pedestrian accessibility considered as an important factor in developing a Transit Oriented Development (TOD) concept to improve peri-urban developments. Depok Baru Station is having a potential value to be expanded as a TOD area in order to support Jabodetabek urban planning. This paper aims to figure up the pedestrian accessibility levels in Depok Baru Station based on time by calculating the pedestrian walking time during transfer modes. Adopting Public Transportation Accessibility Levels (PTAL) methods, this paper will measure accessibility index (AI) using the primary data from direct observation and secondary data from related data documents. Research findings deliver accessibility index (AI) value from two modes namely commuter line and local public transport as the basic knowledge to be considered as a TOD component.

**Keywords:** *accessibility, transit oriented development, PTAL methods.*

## 1. Introduction

Indonesia is experiencing an increasing demand for mobility and significant transportation demand due to the urban development [1]. City focused developments such as infrastructure development, social facilities and public facilities encourage the development of industry and trade that has an impact on urban economic growth [2]. Population growth and urban economic generate a high number of trip volume both people and goods [3]. Recently the big cities growth tends toward urban sprawl which impact to the length of time and trip distance. The main consequence of this condition is the congestion in urban areas that affect to the environmental and society psychological problems. However, volume of transport energy consumption and vehicle emission production can be substantially reduced with compact-city development [4] which focusing on central multi-functional area development that beneficially reduce trip distance and transport energy consumption [5].

The peri-urban is such a zone presenting a transition or interaction zone between urban and rural areas. And due to geographical proximity, the periphery of the city center appears to be functionally integrated with and influenced by the city center [3]. As cities expand, the main zone of direct impact is the peri-urban area. The low cost of commuting from peri-urban areas to the city center coupled with relatively low rent at the peripheries of cities in many developing countries are facilitating the growth of the peri-urban areas. At these peri-urban communities, development is patchy, scattered and spread out, with a tendency for discontinuity. A pattern of uncontrolled development around the periphery of a



city is called urban sprawl and it is an increasingly common feature of the built environment especially in the industrialized nations [6]. Urban sprawl involving the poor occurs because authorities pay little attention to slums, land, services, and transport. Typically urban sprawl associated with overdependence on personal motorized transport coupled with a lack of alternatives, limited housing options, and urban spaces that discourage pedestrian traffic [7].

One of the peri-urban regional development alternative is transit-oriented development (TOD) application to solve the urban sprawl problem and dependency to the private mode transport [8]. TOD concept offers development pattern around transport nodes such as terminal and station which located in densely populated areas by integrating facilities to pedestrian and easy access to various modes of transportation [9]. TOD has been applied in many countries and provide benefits of accessibility; city-compact development and eco-friendly. TOD also encouraging movement from private modes to public transport modes; increasing economical scale of urban areas; and reduce transport expenses [10].

Public transportation plays a key role in ensuring accessibility to activities and services. There are many influences on the use of public transport, including spatial access, cost, physical accessibility, information, and attitudes, all of which contribute to people's ability and motivation to use public transport. In delivering public transport accessibility goals and targets, service planning makes assumptions about walking distance to access public transport. Assumptions about distances that people will walk to access public transport or "rules of thumb" are used not only by transport planners to determine stop spacing, but also by land-use planners for urban design to achieve walkable cities and plan transit-oriented development [11].

## **2. Case study and method**

### *2.1. Case study*

Jabodetabek (Jakarta, Bogor, Depok, Tangerang, Bekasi) start to applied TOD concept following the development of several transportation modes such as train, LRT, MRT, busway and feeder systems under a management of transportation network. The main target of TOD implementation in Jabodetabek area is to develop train station integrated to neighborhood and potential to growth rapidly [12]. The area around station naturally runs into an increase of economic growth, population and settlement area, business area, office, market and another centre of activities. Depok Baru station is one of the TOD location planning since Depok is counted as peri-urban area of Jakarta that produce huges of daily trip to Jakarta. Having a high activity level with complex mixed used areas, generally Depok depends on train as public transportation mode besides private modes to facilitate movement from Depok to Jakarta and vice versa. Statistical data shows that there is an increase of KRL passengers amount 27% from 2015 to 2016. However, this increasing is not directly proportional to the percentage of train mode share in Depok particularly and in Jabodetabek generally. Study of JUTPI [13] on master plan of transportation in Jabodetabek [14] shows that train mode share in Jabodetabek still below of 3%.

Many factors affecting to the shrinkage of train user, one of them is provision of facilities that do not accomodate the flexibility and accessibility of user movement. Generally, Depok Baru station area and surround has potentially to be developed into transit-oriented nodes with the emphasis on accessibility levels of user (pedestrian) to activities and services which starts from transfer modes activities. This paper aims to figure up the pedestrian accessibility level in Depok Baru Station based on time by calculating the pedestrian walking time during transfer modes from train to mini busses and vice versa. The results will be reviewed from TOD perspective to deliver basic knowledge of TOD component, particularly in peri-urban area.

### *2.2. Methodology*

This research applies PTALs (Public Transport Accessibility Levels) to measure accessibility of a point/node to transportation networks by considering pedestrian walking time and the availability of transportation services [15]. Walking times are calculated from specified point(s) of interest to all public transport access point. PTALs then incorporates a measure of service frequency by calculating an average waiting time based on the frequency of services at each public transport point. A reliability factor is added and total access time is calculated. A measure known as an Equivalent Doorstep

Frequency (EDF) is then produced for each point. These are summed for all routes within the catchment and the PTALs for different modes are then added to give a single value [16].

PTALs describe four elements of accessibility namely (a) walking time from the point-of interest to the public transport access point; (b) the reliability of the service modes available; (c) the number of services available within the catchment; and (d) the level of service at the public transport access points. It does not consider the speed or utility of accessible services; crowding; and ease of interchange. PTAL method can be broken down into a series of stages as follows:

- Define the point of interest (PoI)
- Calculate the walk access time (WAT) from PoI to the service access points (SAPs)
- Identify valid routes at each SAP and calculate average waiting time (AWT)
- For each route at the SAPs calculate the minimum total access time (TAT)
- Convert TAT to equivalent doorstop frequencies (EDF) to compare the benefits offered by routes at different distances
- Sum all EDFs with a weighting factor in favour of the most dominant route for each mode
- PTALs are then determined using 6 banded levels as shown in

WAT are measured from the PoI to the SAPs using survey. AWT is the average time between when a passenger arrives at a stop or station, and the arrival of the desired service. In PTALs passengers are assumed to arrive at the SAP at random. For each selected route AWT is calculated by formula (1) as follows:

$$AWT = \frac{K}{2} \times \frac{60}{\text{frequency}} \quad (1)$$

Where K is reliability factor of waiting times modes that can be calculated by assumption. K for train is 0.75 and K for buses is 2.

TAT is made up of a combination of WAT and AWT with formula (2) as follows:

$$TAT = WAT + AWT \quad (2)$$

TAT is converted to an EDF of every passenger in each PoI following formula (3) below:

$$EDF = \frac{30}{TAT \text{ (minutes)}} \quad (3)$$









For a single transport mode the accessibility index (AIs) can be calculated using formula (4) below:

$$AI_{mode} = EDF_{max} + (0.5 \times \text{all other EDFs}) \quad (4)$$

Calculating the overall AI is a sum of the individual AIs over all modes using formula (5) as follows:

$$AI_{poi} = \sum (AI_{mode1} + AI_{mode2} + AI_{mode3} \dots AI_{mode n}) \quad (5)$$

The final formula given above now can be allocated to bands of PTALs in .

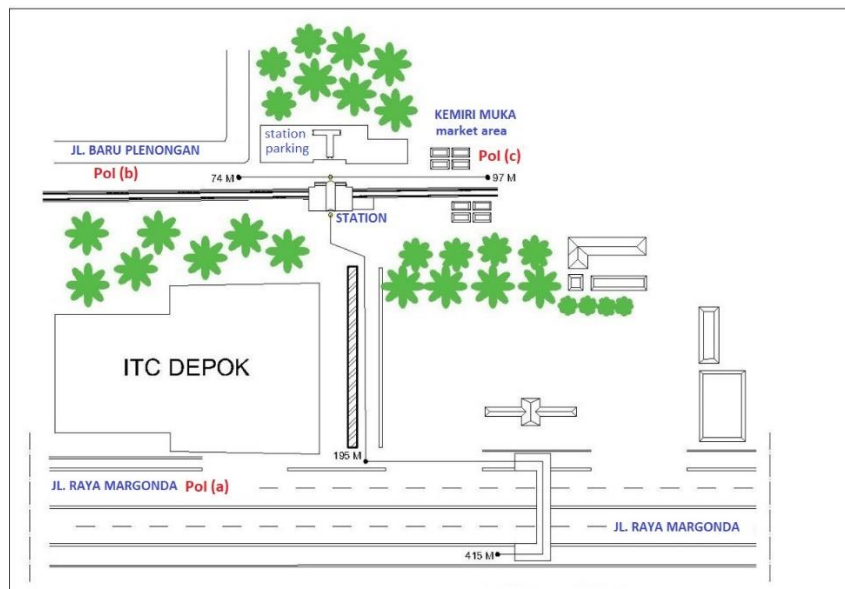
PTAL	Range of Index	Map Colour	Description
1a (Low)	0.01 – 2.50		Very poor
1b	2.51 – 5.00		Very poor
2	5.01 – 10.00		Poor
3	10.01 – 15.00		Moderate
4	15.01 – 20.00		Good
5	20.01 – 25.00		Very good
6a	25.01 – 40.00		Excellent
6b (High)	40.01 +		Excellent

**Figure 1.** PTALs indicator

Source: Transport for London, 2010

### 2.3. Data and information

There are 100 respondents involved in this intercept survey with simple random sampling method to calculate accessibility indexes for train and mini buses. Those respondents as shown in *Figure 2* taken from point of interests in three pedestrian path around Depok Baru station, namely (a) Jl. Raya Margonda – Depok Baru station, (b) Jl. Baru Plenongan – Depok Baru station, (c) Kemiri Muka market area – Depok baru station and vice versa. Sample has taken during 6 am up to 6 pm by dividing it into 4 duration that is (a) 6 – 9 am, (b) 9 – 12 am, (c) 12 am – 3 pm, (d) 3 – 6 pm.



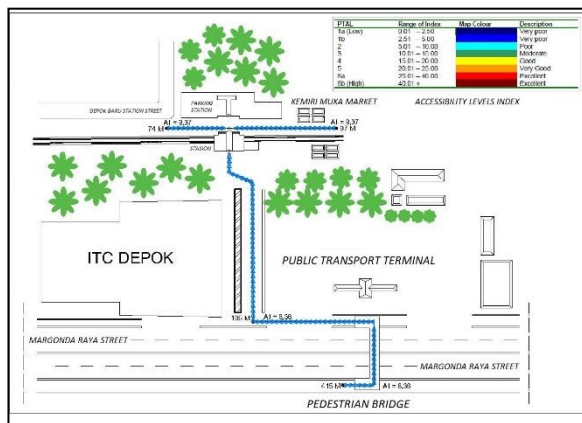
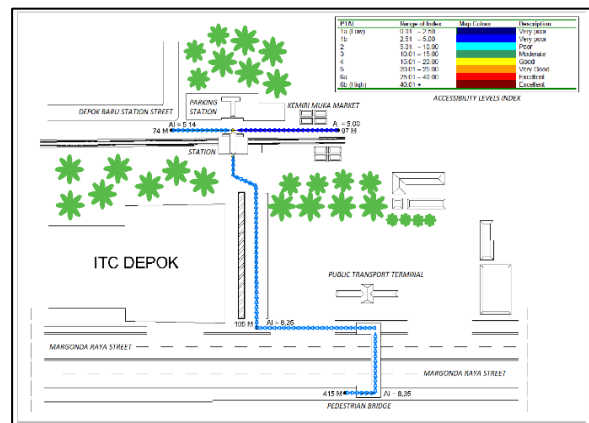
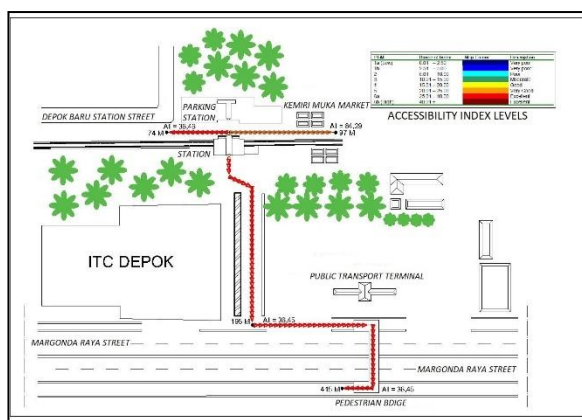
**Figure 2.** Location of PoI (point of interest)

WAT is measured by direct observation to the respondents using stopwatch. Service frequency survey for mini buses also conducted along with this stage, meanwhile service frequency data for train can be obtained by using travel train charts issued by Directorate General of Railways. This stage generate primer data, while secondary data gained from station map to display station layout and from Google Earth to calculate the length of walking path.

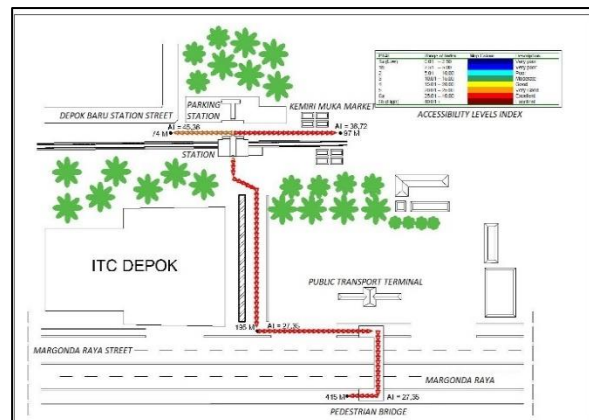
## 3. Result

### 3.1. Accessibility Index

Travel pattern in Depok Baru station is typical for peri-urban areas. In the morning time people travel to their destination such as workplace using train and end up with return trip in the evening time using train and mini busses as transfer mode choice. Therefore, two time periods in the morning (6 – 9 am and 9 – 12 am) used to calculate accessibility index for train and the rest of periods used to calculate accessibility index for mini buses. Accessibility index (AI) measurement results as shown in Figure 3 to Figure 6 below.

Figure 3. AI<sub>(train)</sub> period 6 – 9 amFigure 4.  $AI_{(\text{train})}$  period 9 – 12 am

**Figure 5.** AI<sub>(mini busses)</sub> period 12 am – 3 pm

Figure 6. AI<sub>(mini busses)</sub> period 3 – 6 pm

AI results shows that average waiting time (AWT) for train is 16,5 minutes and AWT for mini busses is 0,62 minute. This means that people need to wait longer to catch the train compared to mini busses since the K factor of train is amount 5,5 and mini busses is 1,41. In other words based on PTALs method, Depok Baru station have poor accessibility indexes on train and excellent accessibility indexes for mini busses. Intercept survey of pedestrian in Depok Baru station obtained that the number of pedestrians is dominated by male with 63% while female is 37%. Majority of pedestrians age are in a range of 25 – 34 years old around 36% and the fewest with 8% share are in range of 15 – 24 years old. *Table 1* below is an example of AI(train) calculation in Jl. Raya Margonda – Depok Baru station using series stage of PTALs Methodology. All AI calculation then accumulated and summarized in Table 2 based on PTALs band indicators in .

**Table 1.** AI(train) calculation in ) Jl. Raya Margonda – Depok Baru

Resp.	Sex	Age	WAT	Sch. Freq	AWT	TAT	EDF
1	L	25 - 34	2,5	10	16,5	19	1,58
2	L	55 >	2,67	10	16,5	19,17	1,56
3	L	25 - 34	3,22	10	16,5	19,72	1,52
4	L	35 - 44	3,22	10	16,5	19,72	1,52
5	L	25 - 34	4	10	16,5	20,5	1,46
6	L	45 - 54	3,82	10	16,5	20,32	1,48
7	P	25 - 34	2,93	10	16,5	19,43	1,54
8	L	55 >	3	10	16,5	19,5	1,54
9	P	35 - 44	3,95	10	16,5	20,45	1,47

Resp.	Sex	Age	WAT	Sch. Freq	AWT	TAT	EDF
10	L	25 - 34	3,98	10	16,5	20,48	1,46
EDF MAX							1,58
AI <sub>(train)</sub>							8,36
PTALs band indicator							Poor

**Table 2.** Summary of AI indexes in Depok Baru station

periods	AI indexes in point-of-interest		
	Jl. Raya Margonda	Jl. Baru	Area Pasar
AI <sub>(train)</sub> 6 – 9 am	8,36	9,37	9,37
AI <sub>(train)</sub> 9 – 12 am	8,35	5,14	5,00
AI <sub>(mini busses)</sub> 12 am – 3 pm	36,45	36,46	84,29

### 3.2. Accessibility as a TOD component

Depok Baru station has been promoted as one of TOD planning due to the existing condition that suitable for TOD development. Depok Baru station having initial characteristics that meet TOD principles particularly in transport characteristics such as park and ride facilities, pedestrian path facilities, various choices of transport modes, located near of shopping center, traditional market, bus terminal, highway road and connected to the residential area. Located in a peri-urban areas which has a potential value of development, Depok Baru area is adequate to linked with Jakarta as city center and another peri-urban area. Therefore Depok Baru is able to provide various of economical center, social center, employment opportunities and other community services and facilities.

From the various definitions of TOD, Queensland Municipality summarizes TOD characteristics in TOD Guide for practitioners in Queensland Australia [19]. There are three main characteristics which requires accessibility levels, namely: (a) a rapid and frequent transit service; (b) high accessibility to the transit station; (c) reduces rates of private car parking. Excellent accessibility levels to the transit station with a rapid and frequent transit service will encourage private modes users into public transport users and actualize the energy saving as one of the purpose of sustainable TOD.

This study discover that train accessibility in Depok Baru station currently counted as poor category, while accessibility into mini busses counted as excellent category. In order to achieve goals and targets of TOD, accessibility levels is one of the main consideration. Unfortunately in Indonesia does not have an accessibility level measuring instrument yet, however accessibility aspect has become one of the key performance indicator of Jabodetabek transportation [14] which is limited by interpreting accessibility as just a distance. There are no consideration about another aspects of accessibility such as time and cost.

## 4. Conclusion and recommendation

According to the analysis results, our study concludes that accessibility index of train in Depok Baru station need to be improved by increase the arrival frequency of train. In addition to reduce the average waiting time this action potentially compound capacity of train in order to meet the demand of trip movement. Besides, measurement tools of accessibility level from many aspect need to be defined after previously agreed on a common perception about accessibility in TOD principles.

## 5. References

- [1] Agence Francaise Developpement, Menemukan Solusi Transportasi Perkotaan: Tantangan Pembiayaan dan Integrasi Jaringan, AFD, Bandung, 2014.
- [2] P. Hao, R. Sliuzes and G. S., The development and redevelopment of urban village in Shenzhen, *Habitat International*, pp. 214-224, 2010.

- [3] H. S. Hasibuan, T. P. Soemardi, R. Koestoer and Moersidik, The Role of Transit Oriented Development in constructing urban environment sustainability, the case of Jabodetabek, Indonesia, *Elsevier Procedia Environmental Sciences*, pp. 622-631, 2014.
- [4] A. B. Arief, M. I. Ramli, A. Akil and A. Yudono, Prinsip-prinsip Transit Oriented Development (TOD) Pantai, berbasis potensi pelabuhan rakyat Kayu Bangkao Makassar, in *Prosiding Temu Ilmiah IPLBI*, Manado, 2015.
- [5] M. Breheny, The Compact City and Transport Energy Consumption, *Trans Inst Br Geogr NS* 20 81-101, pp. 81-101, 1995.
- [6] P. B. Cobbinah and C. Amoako, Urban Sprawl and the Loss of Peri-Urban Land in Kumasi, Ghana, *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering*, vol. 8, p. 313, 2014.
- [7] J. K. Brueckner, Urban Sprawl: Diagnosis and Remedies, *International Regional Science Review*, vol. 23, no. 2, pp. 160-171, 2000.
- [8] N. L. A. Widyahari and P. N. Indradjati, Potential of Transit-Oriented Development and its opportunity in Bandung Metropolitan Area, *Procedia Environmental Sciences*, pp. 474-482, 2015.
- [9] CTOD, Station Area Planning Manual, CTOD, United States, 2007.
- [10] H. Ditmarr and G. Ohland, The New Transit Town: Best Practices in Transit-Oriented Development, Island Press, 2004.
- [11] R. Daniels and C. Mulley, Explaining walking distance to public transport: The dominance of public transport supply, *The Journal of Transport and Land Use*, pp. 5-20, 2013.
- [12] B. D. J. Rencana Tata Ruang Wilayah 2030, Jakarta, 2010.
- [13] JUTPI, Jabodetabek Urban Transport Policy Integration, JICA Japan, Jakarta, 2012.
- [14] B. Kemenhub, Rencana Induk Transportasi Jabodetabek, 2015.
- [15] S. Abley and R. Williams, Public Transport Accessibility Levels, 2008.
- [16] Transport for London, Measuring Public Transport Accessibility Levels, London, 2010.
- [17] S. Abley and R. Williams, Public Transport Accessibility Levels, 2008.
- [18] Transport for London, Measuring Public Transport Accessibility Levels, Transport for London, London, 2010.
- [19] State of Queensland, Transit oriented development: guide for practitioners in Queensland, Brisbane: Australian Department of Infrastructure and Planning, 2010.