KnE Social Sciences

UICRIC 2018
UNNES International Conference on
Research Innovation and Commercialization 2018
Volume 2019

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Conference Paper

Implementation of the Integrated TOD Spatial Model for Jakarta Metropolitan Region

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Abstract

Jakarta Metropolitan Region (JMR) is the biggest megacity urban areas in Indonesia. However, the existing public transport facilities are not adequately fulfilling the demand of its inhabitant. Therefore, it is important for overcoming those issues with shed light on the integration of spatial and transportation by applying Transit Oriented Development (TOD) model. The method of this paper using the spatial and transportation approach by differentiates TOD each railway stations based on the typology. The results were that the TOD spatial model is focusing on solving public transport issues related to urban planning. Therefore, certain policy from stakeholders for this region greatly encourages transport planning in a more sustainable manner.

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Received: 21 May 2019
Accepted: 26 June 2019
Published: 7 July 2019

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the UICRIC Conference Committee.

1. Introduction

Land use and transportation are the key factors to urban and regional planning [1]. The well-regulated city is characterized by the conditions of land use and transportation systems and it indicates economic prosperity. However, there is a tendency that the city development is followed by the various issues of transportation and land use [2]. These issues include traffic congestion, energy wastage, delayed travel time, air and sound pollution. This is a complex problem that involves many aspects and interrelated. Thereby, many researches were conducted to pursue the solution of these issues. Most previous studies examine the application of TOD in Indonesian cities [3]. Nevertheless, lack of study determined the typology of TOD at the regional and urban levels as well as improving transport and spatial planning in an integrated manner. Therefore, this study introduces an integrated TOD as spatial model to guide transport planning of JMR [4].

Transit Oriented Development is a pattern or concept of urban planning with synergized and integrated transportation by accommodating new growth, strengthening the living environment, expanding options and benefits, through the optimization of public transport networks, such as buses and trains, making it easier for residents to

access city resources creating an efficient city [5]. The TOD area is a mix of residential areas with commercial areas and transit stop or stations (train, metro, tram, bus) [6], surrounded by the development of high-density areas or the denser areas to spread out of the centre [7]. The TOD area is generally within 400-800 meters of radius from the transit stop, as this is a suitable distance for pedestrians, so this is a solution to the problem of distance barriers between the stations to the residential area [8].

Initially, the concept of Transit Oriented Development (TOD) emerged as a reaction to the urban sprawl phenomenon followed by high population depends on the use of highways and private vehicles [9]. Proposed TOD as one of the most sustainable forms of urban development and has been practiced in many cities of the world to reduce the dominance of private vehicle use and promote a viable settlement pattern in carrying transit-based movements [10]. in their studies applied TOD in the big cities of the world and reported that the area around the transit point gives an influence in attracting much passenger [11]. The results of other TOD studies pointed out that the diversion of vehicle usage from private to public transport is influenced by the design of the area around the transit node. It indicates the need for integration of regional planning around transit sites with network planning and transportation facilities to be developed.

2. Area of Study and Data

2.1. Transportation plan of JMR

A railway system of Jakarta Metropolitan Region services Jakarta, Bogor, Depok, Tangerang, and Bekasi. The rail system uses rapid transit rolling stock standard and operates at high frequency with a minimum headway. The network route is recognized by Table 1 and Figure 1 below.

Table 1: List of datasets.

Lines	Services	No. of stations	Length
Bogor	Jakarta Kota to Bogor	26	54.8 km (34.1 mi)
Serpong	Tanah Abang to Serpong	7	55.6 km (34.5 mi)
Bekasi	Jakarta Kota to Bekasi via Pasar Senen	13	26.5 km (16.5 mi)
Tangerang	Duri to Tangerang	8	19.2 km (11.9 mi)

Figure 1: Railway route of JMR.

2.2. Datasets

The data in this research is spatial data related to land use and attributes data related to transportation. These table were obtained by using a data collection method with secondary survey technique. Secondary survey is to conduct an institutional survey and survey of literature sourced from previous researches. In addition, there are also government documents and other documents that can support the analysis process in this study.

Table 2: List of datasets.

Datasets	Source	Year
Administrative boundaries	Geospatial Information Agency	2015
Land use	Ministry of Transportation	2014
Railway network and stations	Ministry of Transportation	2015
Actual TOD map	Previous research	2017
Potential TOD map	Previous research	2017

3. Methodology

3.1. Conceptual framework

The methodology is done by studying the literature about the concept of TOD, land use, and transportation, collecting and analyzing spatial and non-spatial data. The finding of study is obtained by creating an integrated TOD by combining actual and potential TOD, differentiating TOD based on typology, afterward implementing the integrated TOD spatial model to guide transport planning.

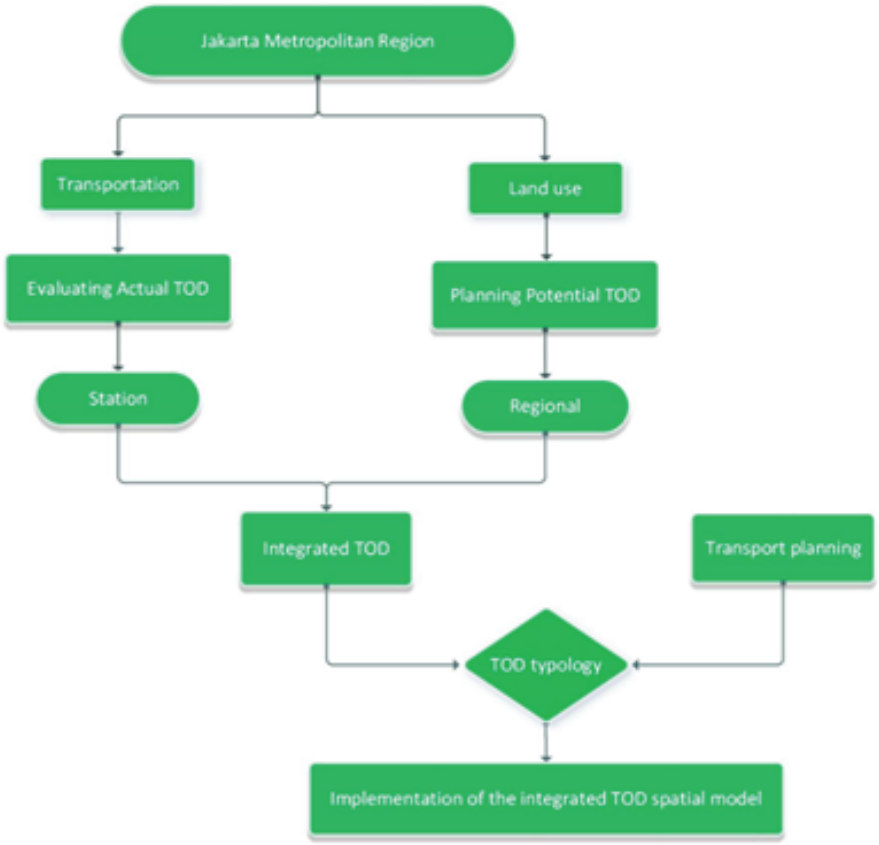


Figure 2: Conceptual framework of the study.

4. Result and Discussions

4.1. Planning concept appropriate to employ TOD

The transport network pattern of JMR is the radial system and spatial form is the multinucleated urban structure with corridors and nodes [12]. It means that the intense land uses in this structure are extended out from the CBD along major transportation routes. [13] promote to the placement of TOD on that location with the proposal like

Figure 3 below. Placement of stations and railways right on the hub and passing the entire main cities of this region.

Figure 3: Public transport network plan [13].

The development proposal of BRT, LRT, and MRT with TOD is designed to cover the entire JMR area by looking at physical conditions of land use and available road network [14]. Improvisation of this public transport connecting sub-urban and urban areas between Jakarta and surrounding area, with good ties is expected to create solutions from various issues that occur such as congestion and environmental pollution.

4.2. TOD typology

TOD typology is done by grouping transit areas according to existing conditions so that it is useful to identify potential TOD.[15] introduced the TOD typology into Urban and Neighborhood TOD. This study distinguishes different TOD typologies based on their development location. as in metropolitan areas, regions have not developed, and regions are experiencing urbanization. [16] gave typology a TOD Regional Center, Urban

Center TOD, TOD Suburban Center and Transit-Town TOD. In this study of TOD typology is limited to Regional, Urban and Suburban with the following explanation:

4.2.1. Regional TOD

TOD with regional service centers, namely the development of the region as a center of economic activity and regional community. This TOD creates synergy between the community and the region, between work and settlement, between the level of density and service, between individuals and society. identify the TOD Regional with the presence of thematic land-use mix, with the dominance of the building environment served by various modes of transportation in a network.

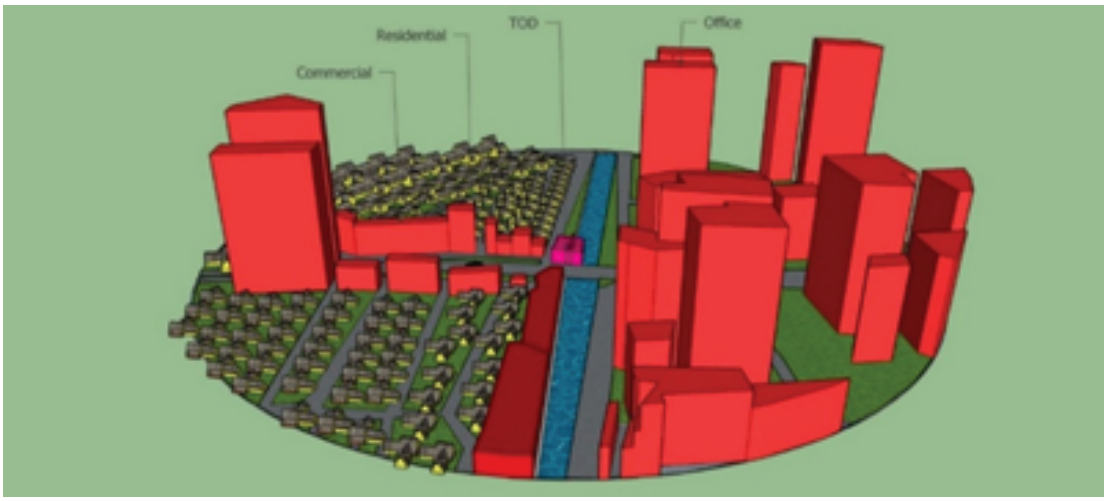


Figure 4: Landscape of Regional TOD.

4.2.2. Urban TOD

TOD with the city service scale, which is the character of urban development as the primary functioning economic center in the main circulation path of the city such as intercity bus stops and train stations both light rail and heavy rail. Urban TOD was developed in conjunction with commercial functions that have high intensity, office blocks, and high-density dwellings. Planning of TOD patterns have a high density because it allows direct access to transit points without having to change other modes.

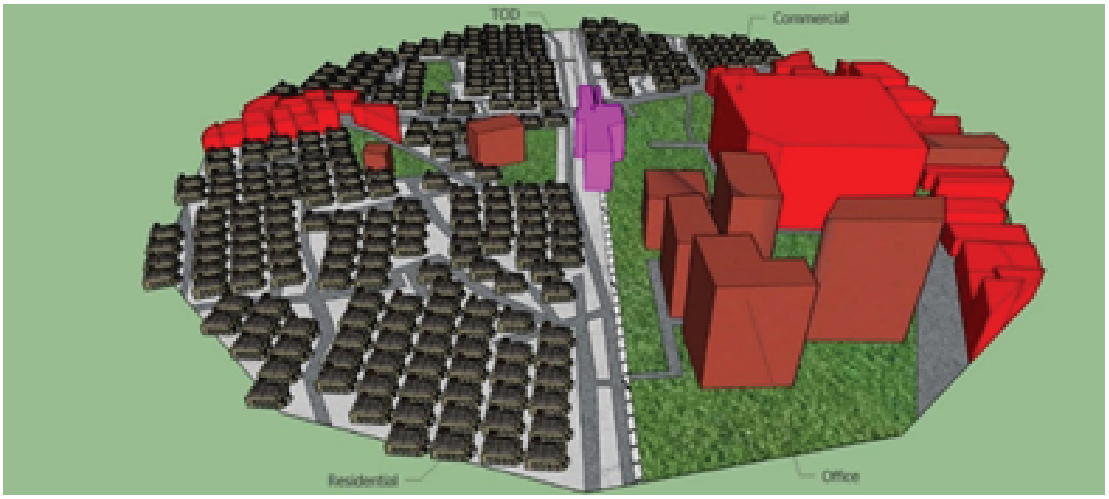


Figure 5: Landscape of Urban TOD.

4.2.3. Suburban TOD

TOD as a sub-city service center. TOD located on the feeder bus lane is in a medium density residential environment, public, service, retail and recreational facilities. Local residences and shops must be adapted to the context of the environment and the level of transit services. This concept also helps the development of housing for the middle to lower class, with the possibility of mixing a variety of dwellings. Suburban TOD is equipped with public facilities and green open spaces and provides easy access for users of movement mode.

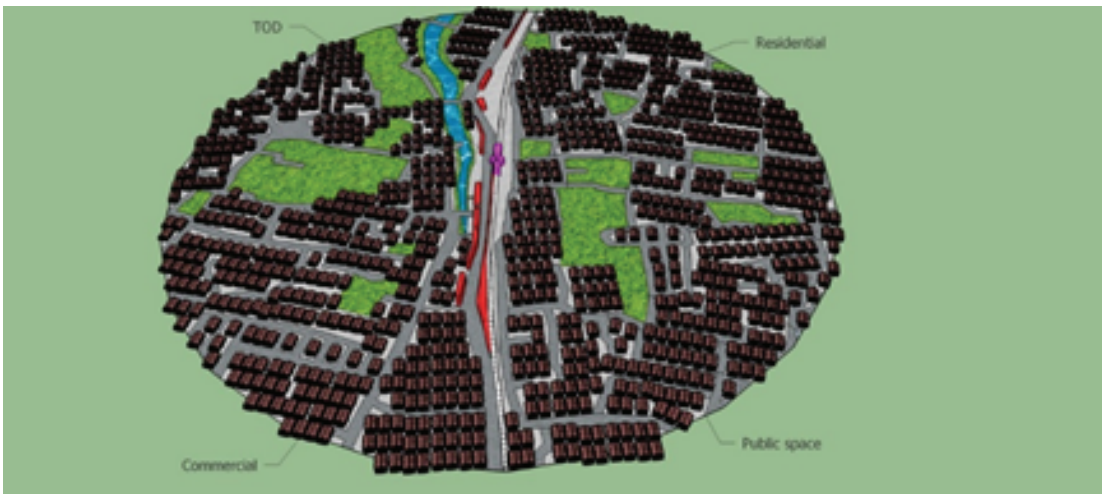
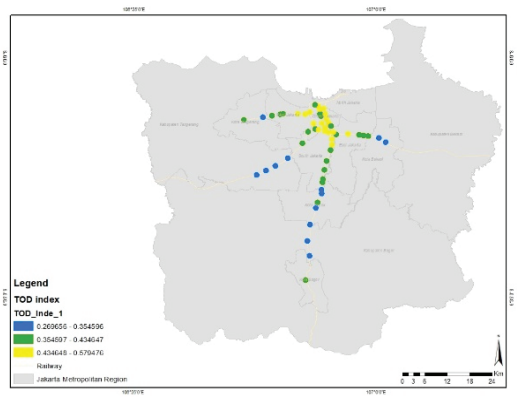


Figure 6: Landscape for Suburban TOD.

4.3. Producing TOD typology based on the spatial model for JMR

The method used in this study is a data analysis from own previous research which has resulted in a basic spatial model for urban transport planning. Data derived from actual and potential TOD which are combined to produce an integrated map of TOD in JMR. The method used for the analysis is multicriteria analysis to get actual TOD and the land suitability evaluation method to get potential TOD. Both methods are supported by AHP techniques to gain priority criteria values and GIS applications to explain spatial in the map.

The evaluation of actual TOD produced the actual TOD index map in the JMR. Actual TOD index means an assessment of the existing station and related to transportation aspect. The unit of analysis carried out based on the node of the train station location, which is explained by the index. The method is used in this study is a combination of AHP and multicriteria analysis technique. The tools used are GIS application to display the resulting map obtained.



Actual TOD means an actual or existing condition of station (transportation)

Potential TOD means a potential location for the new station (spatial)

Figure 7: Actual and Potential TOD.

The planning of potential TOD also from own previous research has been done by with analysis unit is the whole area of JMR. Potential TOD means a potential location for the new station and it relates to the spatial aspect. The method used is the land suitability evaluation method involving 20 criteria to obtain a very potential area for developing a new station. The study is done in more detail by using spatial statistical analysis technique for getting the hotspot area which is very significant for a new TOD station. The results obtained are many clusters of hotspots in the urban center (Jakarta downtown) and few in surrounding areas (Tangerang, Depok, and Bogor).

Figure 8 above shown a station typology of TOD based on actual and potential. This typology is found in the administrative area of JMR. It describes TOD implementation in

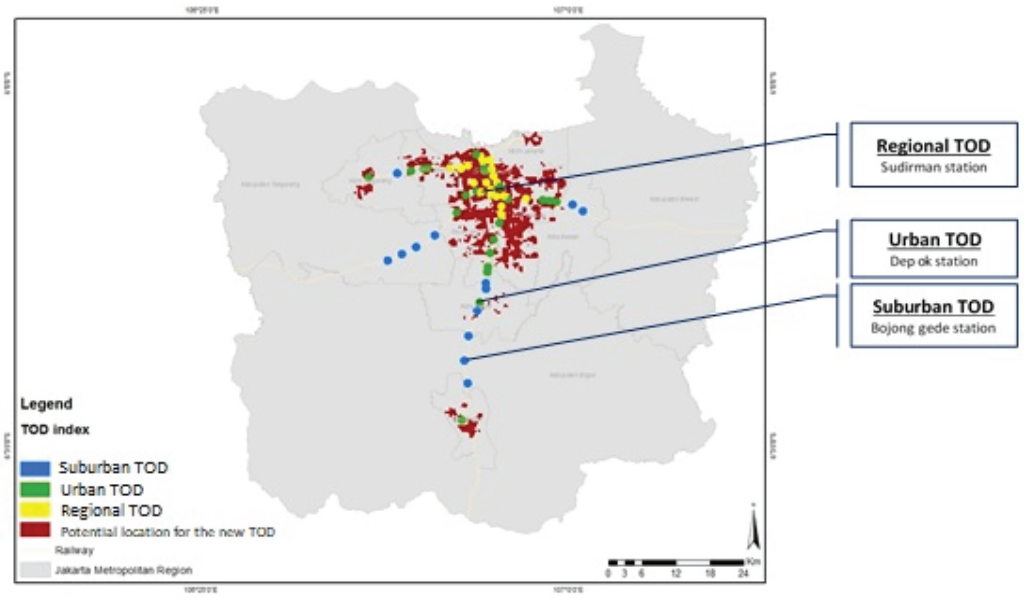


Figure 8: The typology of integrated TOD spatial model.

JMR based on its typology. Each type is taken one example of a station that represents other stations of the same type, this scenario can be used as a model by the government and related parties. Each type is represented by samples such as Sudirman station for Regional TOD, Depok station for Urban TOD and Bojonggede station for Suburban TOD, all these examples represent the whole type of TOD and stations spread throughout the JMR.

Figure 9 above is the implementation of TOD typology into the transport planning in JMR. The figure shows the difference in each station based on TOD typology where the green color indicates the Urban TOD type, the blue indicates Suburban TOD and the yellow color indicates Regional TOD. The application of TOD typology is the finding that conducted in this study.

4.4. Planning scenarios of TOD typology in micro level

Planning TOD is intended for mixed housing or trading lands that are planned to maximize access to public transport and are often added to other activities to encourage the use of public transport modes. Allocation of land around station is developed with difference of density level among buildings. The following Figure 10 shows the TOD zonation in detail based on the distance calculated from the station as the center point.

Transit Oriented Development as a transportation development concept that synergizes with spatial to accommodate new growth by strengthening residential environment

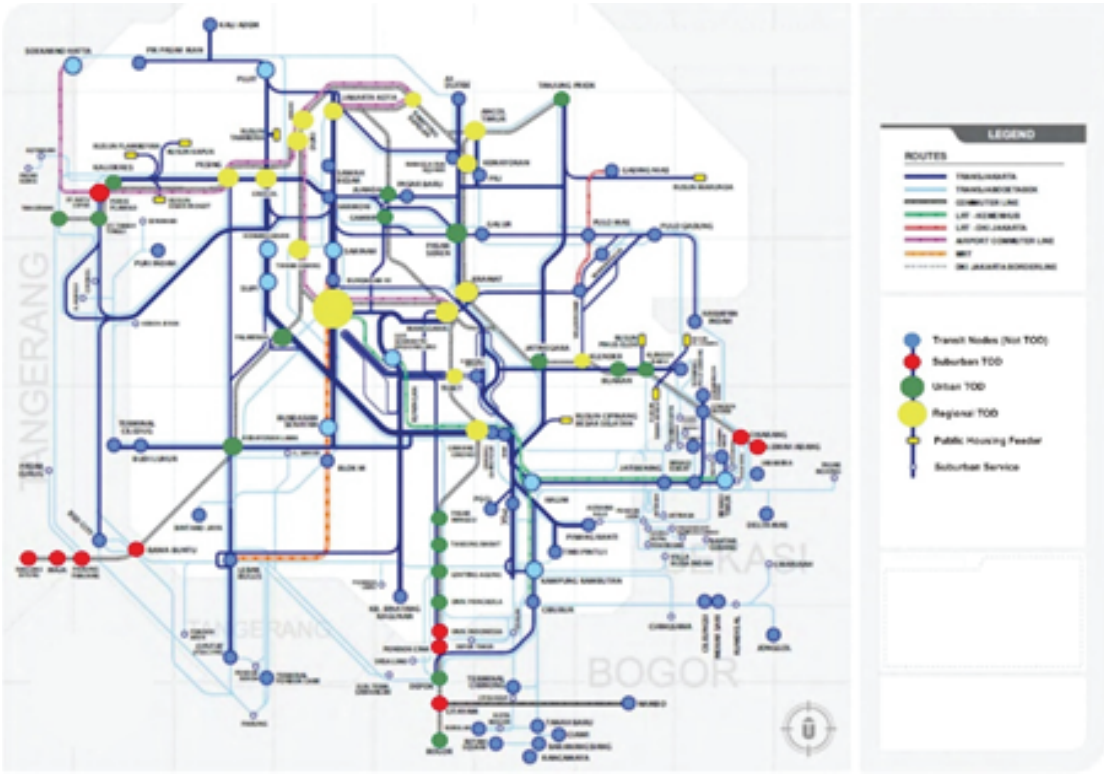


Figure 9: Transport planning of JMR equipped by TOD typology.

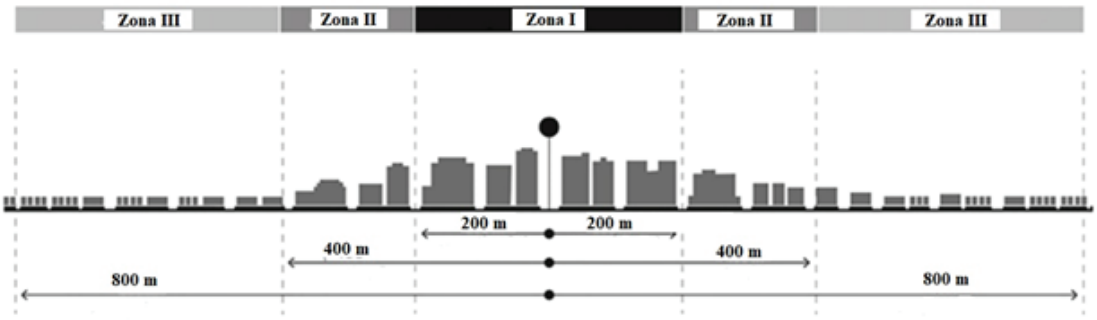


Figure 10: TOD zonation.

and expansion of options and benefits, through the optimization of mass public transport network making it easier for residents to access city resources. The following is a proposed future planning scenario in micro level for the development of the area around TOD applied in JMR region based on its typology.

5. Conclusion and Recommendation

JMR is a metropolitan region including several surrounding cities with the centre is Jakarta capital city. The railway network in the study area connected Tangerang, Depok, Bekasi, and Bogor. Therefore, the TOD become a key actor as the station to service

Table 3: TOD typology.

	TOD typology								
	Regional			Urban			Suburban		
	200m	400m	800m	200m	400m	800m	200m	400m	800m
Sustainability requirement									
Targeted rank of LEED	Platinum	Gold	Silver	Gold	Gold	Silver	Gold	Silver	Bronze
Connectivity requirement									
Maximum length of land (m)	75-120	75-150	120-150	75-120	120-150	150-180	120-150	150-180	120-240
Open space requirement									
Width of pedestrian paths (m)	9-+14	7.5-+10	6-+8	8-+12	6-+10	6-+8	6-+10	6-+8	5-+8
Ratio of public open spaces	10-15%	10-15%	10-15%	10-20%	10-20%	5-15%	10-20%	10-20%	10-20%
Building regulation									
FAR	5-10	3.5-6	1.2-1.8	3-5	2-4	1.2-1.8	2-4	1.5-2	1.2-1.8
Maximum BCR	50%	50%	50%	50%	50%	50%	50%	50%	50%
Maximum number of floors	No control	No control	No control	10	8	3	8	4	3
Active facades*	70-100%	65-90%	50-80%	60-100%	50-80%	<50%	60-90%	60-90%	<40%
Land use									
Ratio of residential	20%	30%	40%	45%	50%	70%	60%	75%	85%
Parking									
Nature of parking	Under-ground/ multi floor	Under-ground/ multi floor	Under-ground/ multi floor	Under-ground/ multi floor	Under-ground/ multi floor	Over-ground	Under-ground	Multi floor	Super-ficial
For every 100 m^2out of the total built up area	1.18-1.66	1.56-1.79	1.44-1.65	1.15-1.51	1.43-1.59	1.23-1.37	1.30-1.46	1.14-1.27	0.94-1.06

residential areas which cover all the regions. Implementation of the integrated TOD spatial model is very helpful to overcome transportations issues. This study developed three type of TOD spatial model namely Regional, Urban and Suburban TOD. It improves services the facilities of public transport service and provides important support for JMR's role as a leading metropolitan region. The conclusion is the planning

of a spatial model of TOD typology help reducing congestion, improving waiting times and overcoming commuter inconvenience.

Acknowledgments

This study was supported by Department of Urban and Regional Planning, King Abdulaziz University (KAU), Jeddah-Saudi Arabia and Faculty of Education, Universitas Negeri Semarang (UNS), Semarang, Indonesia.

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