

Development of Methodology to Evaluate TOD Feasibility in Built-up Environment (Case Study: Jakarta and Bandung, Indonesia)

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Abstract. The major Indonesian cities, among which Jakarta and Bandung, are in the process of constructing and planning urban railway systems, including developing transit-oriented development (TOD) concepts for their stations. For ensuring the targeted ridership and financial sustainability, these TOD plans should be integrated with the mass transit development plan. However, to adopt this is quite challenging since the planned railway lines run through dense built-up environments with limited vacant land available. This study aimed to develop a methodology to evaluate the feasibility of designating built-up environments as TOD areas. The methodology used consists of two elements: (i) a method for determining the suitable TOD typology; and (ii) a method to assess the feasibility of TOD in potential areas based on the requirements of its TOD typology. For the first this study adopted a mixed-method approach comprising of two steps: (i) formulating a set of criteria and indicators based on basic TOD characteristics and the 5 Ds (Calthorpe, 1993; Ewing & Cervero, 2010) as well as related national and local regulations; and (ii) conducting a gap analysis of the transit location characteristics (existing and as part of the spatial plan) based on these criteria and indicators. The methodology was developed based on case studies of potential TOD areas in Jakarta and Bandung. It was found that there are differences between the development requirements based on area characteristics and TOD typologies.

1. Introduction

Transit oriented development (TOD) or transit-based development planning often emerge in discussions on increasing mass transportation system development in the major cities of Indonesia. Basically, TOD is a developmental concept that presents mixed land use integrated with public transportation networks [1].

Developing an area based on TOD aims to minimize the movement of vehicles by ensuring that the population living in the TOD area can work or do their other activities within the area by walking. Meanwhile, if they need to do activities outside the area, they can access public transportation easily and comfortably as the development is designed to make connectivity to and from transportation nodes easier, whether by walking, cycling, or using public transportation systems.

TOD can be implemented in three types of locations [1], i.e. re-developable sites, infill sites, and new growth areas. Re-developable sites are developed areas that can be revitalized. Infill sites are empty spaces surrounded by developed urban areas. New growth areas are undeveloped spaces that are going to be developed, commonly found in newly developed cities or regions. There are main five principles



for implementing TOD, known as the 5 Ds [2], i.e. *density, diversity, design, destination accessibility* and *distance to transit*. The 5 Ds should be implemented in areas that use TOD in such a way that the development can be in line with expectations.

Generally, most TOD in Indonesian cities happens in built-up environments, either re-developable sites or infill sites. Transforming a built-up environment into a TOD area along with its attributes is challenging. From a regulation perspective, in Indonesia there are two legal foundations to guide such transformation: (i) Regulation of the Ministry of Public Works No. 6/2007 on Building and Environmental Design Plan General Guidelines (RTBL); and Regulation of the Ministry of Agrarian and Spatial Planning No. 16/2017. However, these policies do not explain how to develop and apply the TOD provisions according to the area's characteristics.

Accordingly, this study was aimed at developing a methodology for evaluating TOD feasibility specifically in built-up environments, departing from the hypothesis that planning challenges are different in different areas, especially in built-up environments. In some cities where TOD was implemented, mistakes were made, rendering TOD less effective. Examples are Coral Gables, Miami, where pedestrian needs were insufficiently considered, and the development feasibility as reported in *City Lab* [3].

This paper consists of two parts. First a suitable TOD typology is determined and the composition of diversity and floor-area ratio (FAR) of the planned TOD locations are calculated to meet the ridership requirements. A set of development criteria and indicators is formulated based on the 5 Ds and the basic interests of TOD. These criteria and indicators are then used to evaluate the existing characteristics of the planned TOD locations and associated with their spatial plans. The second part contains a gap analysis of the areas (according to existing conditions and spatial plans) based on the criteria and indicators. The output of this paper is the recommendation of a methodology to evaluate TOD feasibility in built-up environments based on the criteria and indicators of the TOD principles and interests, existing characteristics, and spatial plans.

2. Case Studies

Jakarta as the capital city of Indonesia and Bandung as the capital city of West Java Province will develop their railway stations using TOD as part of their spatial plan. In Bandung, TOD will be used for its LRT stations. Bandung City has inserted TOD in their 2011-2031 general spatial plan and detailed spatial plan. TOD was used to support LRT development in the greater Bandung metropolitan area as written in Mayor's Decree Nr. 1175 2015 on Transportation Master Plan of Bandung City. Inside this master plan, nine LRT corridors are planned, two of which are prioritized. In accordance with the LRT development within the transportation master plan, the development is also supported by a presidential draft decree on the acceleration of building an integrated LRT system in the greater Bandung area [4]. Cimindi, Bandara Husein, Pajajaran, Martadinata, Antapani, Gedebage, and Tegalluar are 7 of the 23 planned stations.

In Jakarta, TOD will be implemented for MRT and LRT stations. Jakarta's TOD plan is also included in the macro spatial plan (RTRW) and detailed spatial plan (RDTR). TOD in the MRT line connecting Lebak Bulus and Kampung Bandan will be implemented in two phases, with Lebak Bulus, Fatmawati, and Dukuh Atas Station as well as the areas of Cipete and Blok M in phase I and Depo Kampung Bandan-Ancol in phase II. Furthermore, TOD along the LRT line connecting Kelapa Gading and Velodrome will also be done for 6 stations, i.e. Depo Station in Pegangsaan Dua Kelapa Gading Street, Mall Kelapa Gading Station, Kelapa Gading Boulevard Station, Pulomas Station, Pacuan Kuda Station and Velodrome Station.

3. Methodology

This study used a mixed-method approach to collect and analyze the data. Firstly, a secondary survey among relevant agencies was conducted to identify the prevailing spatial plans and transportation plans. Secondly, a literature study was conducted to compose criteria and indicators based on the 5 Ds and

TOD related regulations. Thirdly, field observation was done to understand the existing conditions in the TOD areas.

Generally, formulating the methodology to evaluate TOD feasibility in built-up environments was done in three main steps, as shown below.

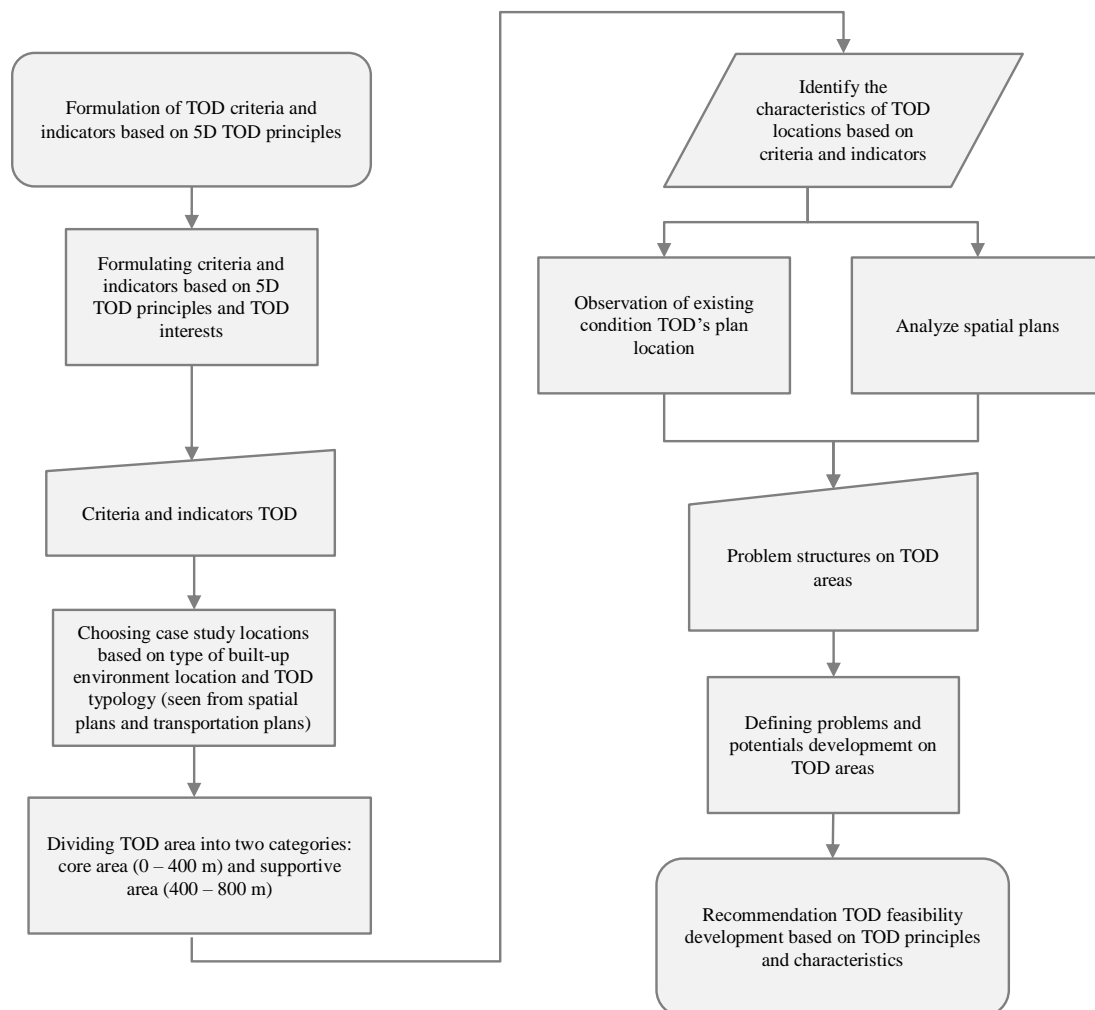


Figure 1. Methodology flow chart.

Basically, the different conditions of the core and its supporting areas will follow several conventions:

- The farther the area is from the station, the more the density and height of the buildings will decrease;
- The nearer the area is from the station, the more diverse and attractive land use will be;
- The denser the area, the wider the pedestrian ways will be;
- There will be limited parking space, especially in the core area. Park-and-ride will be placed in the supporting areas adjacent to the core area;

- The core area will mostly be served by public transportation;
- There will be several feeder public transportation nodes in the supporting areas for the core area.

The next process in composing these guidelines is to compose criteria and indicators based on the 5 Ds. Ewing and Cervero [2] describe these 5 principles as follows:

- Density: the density of the area surrounding the radius of the transit service area that supports the main mass transportation is such that this system works adequately.
- Diversity: diversity of land use and building use per area width, floor width, or employment field.
- Design: integrated design of the spaces between one area and another depends on pedestrian movement and includes traffic patterns, pedestrian facility availability, and bicycle facility availability.
- Destination accessibility: easy access to destinations both inside of the TOD area itself and between TOD destinations citywide.
- Distance to transit: proximity between home or workplace and station, bus station or other public transportation nodes.

Based on the components of each principle, the criteria and indicators can be defined as reference for TOD. The criteria and indicators were composed through reviewing literature on TOD and TOD precedents. For example, *MARTA* [5], *Reconnecting America's Center for Transit Oriented Development or FTA* [6], *Department Planning, Property, and Development City of Winnipeg or DPPDCW* [7], *Land Use Planning and Policy Department City of Calgary or LUPPDCC* [8], and *ITDP* [9]. The criteria and indicators are also based on the TOD typologies. Even though the basic principles of TOD seem to be the same in all contexts, their specific application greatly differs in form, function and impact, calling for context-based TOD. The typology of TOD can help to map local specificities and better focus policy interventions [9]. Below are the criteria and indicators that were composed to identify the conditions at the planned TOD locations.

Table 1. TOD Criteria and Indicators. [2, 6, 7, and 12]

Criteria	Indicators				
	Regional Center	Urban Center	Urban Neighborhood	Suburban Center	Special Uses
Density	Minimum FAR is 5.0 or 4 – 30 stories	Minimum FAR is 2.5 or 2 – 20 stories	Minimum FAR is 1.0 or 2 – 5 stories	Minimum FAR is 4.0	Minimum FAR is 2.5
Building Density and Intensity Levels	Building Density and Height:	Building Density and Height:	Building Density and Height:	Building Density and Height:	Building Density and Height:
	<ul style="list-style-type: none"> • Core Area: High • Supporting Area: High-Mid 	<ul style="list-style-type: none"> • Core Area: High-Mid • Supporting Area: Mid-Low 	<ul style="list-style-type: none"> • Core Area: Mid - Low • Supporting Area: Low 	<ul style="list-style-type: none"> • Core Area: High-Mid • Supporting Area: Mid 	<ul style="list-style-type: none"> • Core area: mid, depend on their function • Supporting area: mid-low, depend on their function
Diversity	At least consists of:	At least consists of:	At least consists of:	At least consists of:	At least consists of:
Land Use Diversity to Support Various Activities	<ul style="list-style-type: none"> • Employment 	<ul style="list-style-type: none"> • Residential buildings 	<ul style="list-style-type: none"> • Residential buildings 	<ul style="list-style-type: none"> • Residential 	

		<ul style="list-style-type: none">• Residential buildings• Supporting Facilities With commercial land use as the dominant land use	<ul style="list-style-type: none">• Employment• <i>Mixed Use</i>• Supporting Facilities	<ul style="list-style-type: none">• Commercial/ office buildings• <i>Mixed use</i>• Supporting facilities With residential land use as the dominant land use	<ul style="list-style-type: none">• Commercial• Employment• Supporting Facilities	<ul style="list-style-type: none">• 20% residential buildings• 10% retail, commercial or public facilities.
		<ul style="list-style-type: none">• Target number of residential buildings: 8,000-30,000• Target number of employment: 40,000-150,000	<ul style="list-style-type: none">• Target number of residential buildings: 5,000-15,000• Target number of employment: 5,000-30,000	<ul style="list-style-type: none">• Target number of residential buildings: 2,500-10,000• Target number of employments: -	<ul style="list-style-type: none">• Target number of residential buildings: 2,500-10,000• Target number of employment: 7,500-50,000	<ul style="list-style-type: none">• Target number of residential buildings: 2,000-5,000• Target number of employment: 7,500-50,000
Design						
Walk-ability	Encourages walkability	<ul style="list-style-type: none">• Safe and comfortable pedestrian ways• Standardized pedestrian way width and wider pathways for denser areas• Continuous and distinct pedestrian ways• Connected with cross pedestrian ways				
	Parking system that discourages private transportation use	Provision of parking facilities applying the travel demand management principle in order to improve mode transfer to public transportation with different standards and with applicable parking standards. Off-street facilities can be used as park-and-ride.				
	Supports bicycle uses	There is a special bicycle lane and parking/rental center to safely and easily borrow bicycles				
	There is an open space or park to support place making	There is an open space or park that is accessible by walking and able to support interactions between people				
Destination Accessibility						
Easy to access public transportation		Served by all types of public transportation (interprovince, intercity, city, and country)	Served by intercity, city and country public transportation	Served by city and country public transportation	Served by intercity, city and country public transportation	Connected to modes that connect residential and activity centers to special use locations
		There are transport nodes/hubs in the TOD area				
Distance to Transit						
Accessible transit location from the activity core		Coverage of transportation services is accordance with walking distance				

4. Analysis and Discussion

4.1. Identification of TOD Typology

In identifying the normative TOD typology, there are two planning documents that should be consulted, i.e. the regional spatial plans – both macro (RTRW) and detailed (RDTR) – and the transportation system master plan. Based on the regional spatial planning the activity center plan around the planned TOD location was analyzed that will have an impact on the development of the TOD location. This refers to the spatial structure plan. Meanwhile, land use diversity refers to the spatial pattern plan. The transportation master plan provides to other public transportation plans, besides the LRT, that will affect the TOD location (potentially becoming a feeder node). The transportation master plan usually also includes other plans and policies regarding transportation, such as parking space, travel demand management, etc. that can be relevant to TOD implementation.

The following table shows the urban spatial plan and transportation plan at each TOD location.

Table 2. Development and Transportation Plan in TOD Plan Areas.

No	TOD Location	Urban Spatial Plan	Transportation Master Plan
1	Husein Sastranegara TOD Area*	Located in the area of Husein Sastranegara International Airport, which is the only airport in Bandung City. Connecting Bandung City with other regions.	Connect with LRT Corridor II Bandung and will be traversed by Bandung City's bus line plan.
2	Martadinata TOD Area*	There is no specific plan for activity center development around the Martadinata TOD area. However, the Martadinata TOD area is located in the center of Bandung City in a strategic location for commercial and service purposes.	Connect with LRT Corridor II Bandung and will be traversed by Bandung City's bus line plan.
3	Antapani TOD Area*	A residential area development is planned in the Antapani TOD area.	Connect with LRT Corridor II Bandung and will be traversed by Bandung City's bus line plan
4	Kelapa Gading TOD Area**	The Kelapa Gading area is one of the secondary activity centers in DKI Jakarta. Secondary activity centers play a role in serving provincial scale activities. The Kelapa Gading area is located on the outskirts of DKI Jakarta in East Jakarta.	Connect with LRT Jakarta but there is no specific transportation development planning that will traverse the Kelapa Gading TOD area. However, this TOD area can be connected to the TransJakarta BRT.
5	Ancol TOD Area**	The Ancol TOD area is part of the Taman Impian Jaya Ancol coastal tourist destination development planning, thus this area is focused on tourism.	Connect with LRT Jakarta but no specific transportation development is planned that will traverse the Kelapa Gading TOD area. However, this TOD

No	TOD Location	Urban Spatial Plan	Transportation Master Plan
			area can be connected to the TransJakarta BRT.

*located in Bandung

**located in Jakarta

Based on the development characteristics plans and transportation plans of both cities, as mentioned in the table above, we can classify the TOD locations into a TOD typology.

Table 3. Typology of TOD Plan Areas

No	TOD Location	TOD Typology
1	Husein Sastranegara TOD Area*	Regional Center
2	Martadinata TOD Area*	Urban Center
3	Antapani TOD Area*	Urban Neighborhood
4	Kelapa Gading TOD Area**	Sub-urban Center
5	Ancol TOD Area**	Special Uses

*located in Bandung

**located in Jakarta

4.2. Identifications Characteristics of TOD Areas

4.2.1. Characteristics of TOD Areas in Bandung

A. Characteristics of Husein Sastranegara TOD Area (Regional Center Typology)

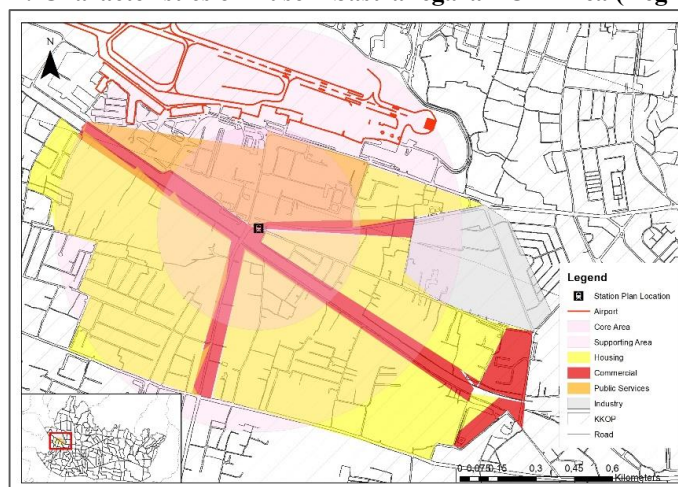


Figure 2. Husein Sastranegara's TOD Map.

Husein Sastranegara TOD area is classified as a regional center according to the urban and transportation development planning. The existing conditions in the Husein Sastranegara Airport area do not fulfill all TOD indicators, particularly those related to the typology of a regional center. Only 4 out of 15 indicators are fulfilled. The indicators density, diversity and design are unfulfilled, but the design principle can be fixed because in Bandung City's *RDTR* there are revitalization plans for the pedestrian ways, which can improve the pedestrian way quality according to TOD standards. As for density,

the average building has 1-2 floors in the core area and 1-3 floors in the supporting areas with an average FAR of 1.2-2.0, which is usually smaller closer to the core area. Furthermore, the location is within a flight operation safety zone, which imposes limitations on development over a certain height. That is why buildings in this location cannot be developed as high-rise buildings, especially in the core area. The core activity has not been planned yet as one of the attractions in this TOD location. As for diversity, land use in Husein Sastranegara is not diverse. Land use is dominated by settlements, while regional centers are supposed to be dominated by commercial land use. It is necessary to adjust the land use according to the TOD principles. Several public transportation modes, such as micro buses (*angkot*) and

city buses, pass Husein Sastranegara. They could function as feeders for the main transit system, which is the LRT. According to the public transportation routes, Husein Sastranegara is well connected with the main hubs of Bandung City.

B. Characteristics of Martadinata TOD Area (Urban Center Typology)

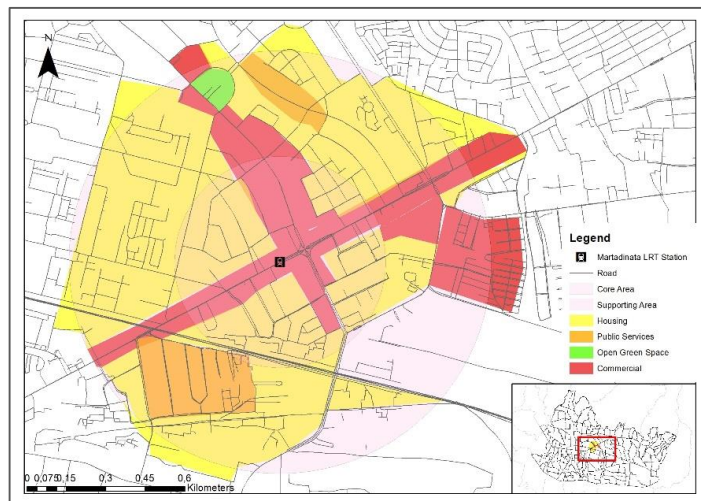


Figure 3. Martadinata's TOD Map.

Bandung City's *RDTR* contains pedestrian way revitalization plans, which can improve the pedestrian way quality according to TOD standards; parking management plans; and bicycle lane plans. Hence, development in this location can fulfill all the TOD principles.

C. Characteristics of Antapani TOD Area (Urban Neighborhood Center Typology)

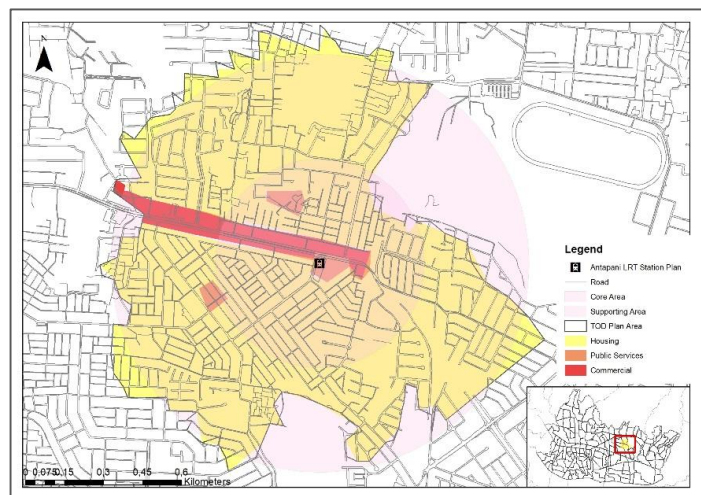


Figure 4. Antapani's TOD Map.

The Martadinata TOD area is classified as an urban center according to the urban and transportation development planning. The existing conditions do not fulfill all criteria; only 6 out of the 15 indicators are fulfilled. Especially the density and design principles are not met. As for density, building intensity in this location is still below the minimum intensity that should be in a TOD, especially according to the typology of an urban center, and the intensity in supporting the areas is higher than in the core area. As for design, the existing conditions can be fixed because

The Antapani TOD area is classified as an urban neighborhood center according to urban and transportation development planning. The existing conditions do not fulfill all criteria; only 5 out of the 15 indicators are fulfilled. The existing conditions mostly do not fulfill the design and distance to transit principles, either of which cannot be fixed because in Bandung City's *RDTR* there is no transportation planned that traverses this area. However, there are pedestrian way revitalization plans, which can improve pedestrian way quality according to TOD standards; parking

management plans; and bicycle lane plans. As for distance to transit, in Bandung City's *RDTR* there is no plan for core activities or addition of *angkot* routes (as feeder).

4.2.2 Characteristics of TOD Areas in Jakarta

A. Characteristics of Kelapa Gading TOD Area (Sub-Urban Center Typology)

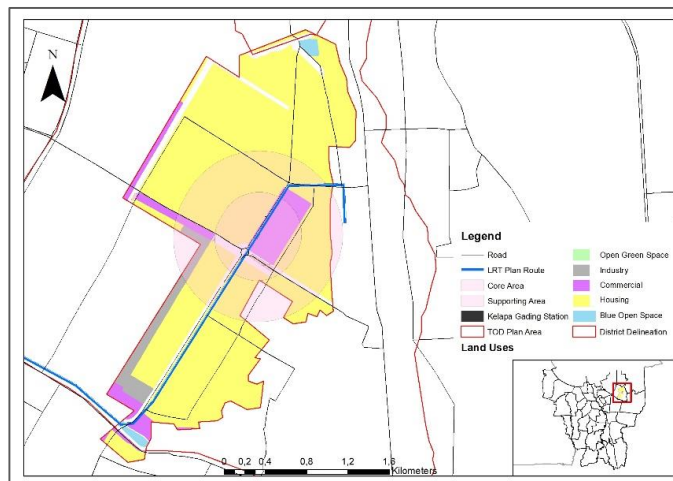


Figure 5. Kelapa Gading's TOD Map.

not in accordance with the provision of this typology. As for design, the existing conditions also do not meet the required indicators but some criteria will be fulfilled because they are listed in DKI Jakarta's *RDTR*.

B. Characteristics of Ancol TOD Area (Special Uses Typology)

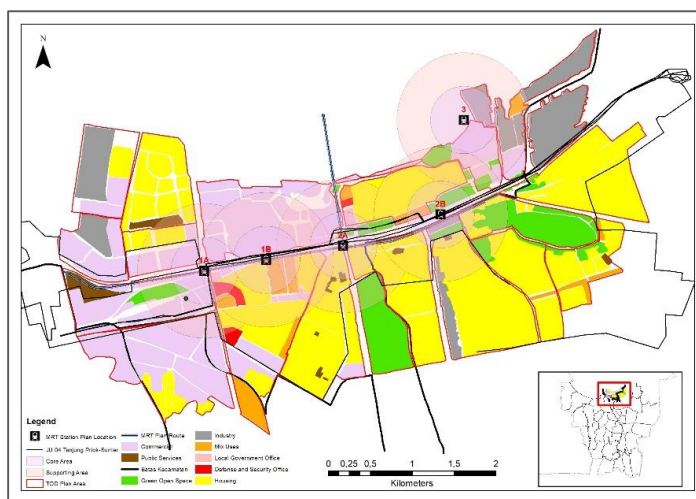


Figure 6. Ancol's TOD Map

be able to support coastal tourism.

Kelapa Gading TOD area is classified as a sub-urban center according to the urban and transportation development planning. The existing conditions of the Kelapa Gading TOD area do not fully fulfill the criteria in terms of density, diversity and design. The existing conditions only fulfill 5 out of the 15 indicators. However, the diversity principle will be fulfilled by the development planned included in DKI Jakarta's *RDTR*. As for density, the building floor coefficient given in DKI Jakarta's *RDTR* is still below the FAR provision for sub-urban centers, therefore the development is

The Ancol TOD area is classified as a special use area according to the urban and transportation development planning. The existing conditions in Ancol do not fulfill all criteria; only 5 out of the 15 are fulfilled. The existing conditions do not meet the density, diversity and design principles. Generally, the existing conditions can also not be fulfilled by DKI Jakarta's *RDTR*, therefore the development of Ancol still has obstacles. Moreover, because of the special use typology, Ancol TOD development is also expected to support tourism development, thus the activities and transit system developed in Ancol should

5. Problem Structure in TOD Areas

This section analyzes the gap between the 5 TOD principles of each typology and the existing location characteristics as described in the previous section. Based on this gap, we obtained the problem structure for each location representing each typology. The following table summarizes the result.

Table 4. Problem Structure of TOD Plan Areas.

Principles	Regional Center		Urban Center		Urban Neighborhood		Sub-Urban Center		Special Use	
	Core Area	Supporting Areas	Core Area	Supporting Areas	Core Area	Supporting Areas	Core Area	Supporting Areas	Core Area	Supporting Areas
Density	The density and height of the buildings do not correspond to the typology, neither in the existing conditions nor in the planning	The intensity of the buildings is not appropriate and the supporting area's intensity is higher than that of the core area	The density is lower than that of the supporting area	The density is higher than that of the core area	There is no problem with the density, but the intensity can still be optimized		The density and height of the buildings do not correspond to the typology, neither in the existing conditions nor in the planning	The intensity of the buildings is not appropriate	The density and height of the buildings do not correspond to the typology, neither in the existing conditions nor in the planning	The density and height of the buildings do not correspond to the typology, neither in the existing conditions nor in the planning
	For locations that have special provisions, make those special provisions a priority		The development is not yet oriented. Vertical and compact development are possible because the intensity in the zoning regulations of Bandung City's <i>RDJTR</i> can be optimized				The development is not yet vertical and compact oriented. The intensity in the core area should have higher intensity than the supporting area		For locations that have a special use, the special use should be made a priority	The intensity in the supporting area should be planned to support special uses in the core area
Diversity	Land-use in the existing conditions and in the development, plans are not various enough and cannot support regional scale activities		Because there are limitations in the land use of the core area, the supporting area is more diverse than the core area				In the core area, land use is dominated by commercial and service activities. This is caused by the location in the city center, which serves as a destination. However, the commercial and service activities are not attractive enough to attract many visitors		There is no problem in diversity, but it can still be optimized and made more attractive	
Design	The pedestrian ways that are available are not sufficient to be used safely and comfortably by pedestrians.									

Principles	Regional Center		Urban Center		Urban Neighborhood		Sub-Urban Center		Special Use		
	Core Area	Supporting Areas	Core Area	Supporting Areas	Core Area	Supporting Areas	Core Area	Supporting Areas	Core Area	Supporting Areas	
Destination Accessibility	<ul style="list-style-type: none">There should be shared parking lots that are located on the border of the core area and the supporting area. Shared parking should be located at the back of building										
	<p>The types of existing public transport serving the core area is still insufficiently diverse. But, there are plans to introduce new routes and modes through the core area. The new public transport needs to be integrated with existing public transport.</p>				<p>There are mass public transport development plans that will traverse the supporting area. They need to be integrated with the existing public transport in order to become good feeders for the core area.</p>		<p>There are no problems with destination accessibility in the core area.</p>		<p>Existing public transport functions as feeder is not sufficient to serve the core area.</p>		
Distance to Transit	<ul style="list-style-type: none">The distance from the TOD location to existing transportation nodes is ± 2.4 km to Bandung Station and ± 4.5 km to Leuwi Panjang Terminal. Husein Sastranegara Airport can be reached by foot.				<ul style="list-style-type: none">The distance from the TOD location to existing transportation nodes is ± 3.2 km to Bandung Station and ± 5 km to Leuwi Panjang Terminal. This is quite far.		<ul style="list-style-type: none">The distance from the TOD location to existing transportation nodes is ± 7 km to Bandung Station and ± 8 km to Leuwi Panjang Terminal. This is very far.		<ul style="list-style-type: none">The distance from the TOD (1st point) location to existing transportation nodes is ± 400 m to Kampung Bandan Station and from 2nd point is ± 200 m to Ancol Station and can be reached by foot.		
	<ul style="list-style-type: none">Existing public transportation does not serve the entire area inside the TOD but only operates along the main road.				<ul style="list-style-type: none">The availability of transit locations in the northern part is better than in the southern part.		<ul style="list-style-type: none">Existing public transportation does not operate along the major street and there is only one route serving this area. The availability of transit in		<ul style="list-style-type: none">The distance from the TOD location to existing transportation nodes is ± 2 km to the Pulomas TransJakarta Shelter. It is quite isolated but it is connected by a microbus service (<i>angkot</i>).		
				<ul style="list-style-type: none">Existing public transportation does not serve the entire area inside the TOD but only operates along the main road.		<ul style="list-style-type: none">The availability of transit locations in the northern part is better than in the southern part.		<ul style="list-style-type: none">Existing public transportation does not operate along the major street and there is only one route serving this area. The availability of transit in		<ul style="list-style-type: none">The distance from the TOD location to existing transportation nodes is ± 2 km to the Pulomas TransJakarta Shelter. It is quite isolated but it is connected by a microbus service (<i>angkot</i>).	

	Regional Center	Urban Center	Urban Neighborhood	Sub-Urban Center	Special Use
Principles	Core Area Supporting Areas	Core Area Supporting Areas	Core Area Supporting Areas	Core Area Supporting Areas	Core Area Supporting Areas
	the northern part is inadequate.				

From the analysis summarized in the table above, every location has different problems. However, in general, none of the areas that were studied fulfill all 5 TOD principles. The plans being drawn in the micro spatial plan, both for Bandung and Jakarta, do not accommodate these principles in the future development of the case study areas.

6. Findings and Discussion

This section further discusses the problem structures encountered at each TOD location if the TOD plans are implemented. From the five TOD locations, as mentioned above, none fulfill the TOD principles. This implies that, in the Indonesian context particularly, when a TOD area is located in a built-up environment, it is necessary to take into account the existing conditions when formulating the best-suited development strategies. While managing the area's development, it is also important to integrate the city development with both the existing and planned transit systems serving the TOD area. More importantly, the fact that the spatial plan does not or limitedly accommodate any of the TOD principles in the future, TOD development will impose a significant bottleneck, among others, in obtaining construction permits.

Based on the problem structures and with the intention of solving the problems that may be encountered in other areas with similar characteristics, the following TOD development guidelines were formulated based on the location plans and typologies.

A. Regional Centers: TOD Located around an Airport

1. In the realization of the density principle in re-developable areas, land consolidation is needed. Limitations on height and density of buildings according to their specific local provisions are prioritized to accommodate the specific provisions. In locations with specific provisions, such as an airport, the density in the core area will be lower than the density in the supporting area, so that the development will be more intensive in the supporting area.
2. Development of the diversity principle can be conducted in accordance with *RDTR* zoning regulations. The diversity of land use should be able to accommodate a variety of activities, especially in the core area. Diversity can be improved both through horizontal and vertical development. However, if there are limitations in realizing high-rise buildings, then diversity can still be done horizontally despite not being a compact form of development. In locations with limited land availability, the adjacent supporting area can be used as service location for the TOD area.
3. Development of the design principle is very feasible if the width of the roads within the TOD area is adequate. The main design principle is to maintain the comfort, security and safety of pedestrians moving within the TOD area. On major roads, vehicles will be relatively faster, in which case a more spacious pedestrian environment with a barrier between road and pedestrian environment should be created.
4. For the development of destination accessibility, the availability of various public transport modes on a regional and local scale as well as the availability of interchange modes to cater to the urban areas are essential. In addition, more than one alternative access to the core area should be provided, considering the large scope of services in this area.
5. Improvement of distance to transit needs to be realized by increasing the coverage of public transport services to support the TOD activities and locations. Besides, there should be an integrated public transportation system that connects both internal and external areas to reach transit locations.

B. Urban and Sub-urban Centers: TOD Located in a City Center

Urban centers and sub-urban centers have similar problem structures and thus the guideline is the same for both cases. The points are:

1. Development of the density principle in a core area with infill site locations is relatively easy because in the core area these are usually located on vacant plots, especially transit

locations. In the supporting areas, density will tend to be adjusted to the conditions in the core area. For example, if the core area is at a location that allows high-rise building in compliance with the *RDTR* zoning regulations.

2. The diversity principle can be developed by locating infill sites. Because the selected locations are on vacant land, it would be more convenient to allow the land use activities to meet the requirements of the core area. On the other hand, if such land use cannot be accommodated, the allowed activities should be optimized in such a way to make the area more attractive.
3. The main design principles that should be prioritized are pedestrian ways and parking management. Pedestrian ways must be developed to maintain the security, safety and comfort of pedestrians, especially in the core area, to encourage walking. Parking management is done to reduce the use of private vehicles. On-street parking is provided in commercial zones for fast shopping, such as minimarkets. Off-street parking is provided in the supporting areas and parking buildings should also be used for other purposes. If possible, parking is preferred for shared use (shared parking).
4. The destination accessibility principle is developed through the provision of various modes of transportation to serve users towards regional and local services. More than one access road to the transit location in the core area should be provided in order to ease the travel to the transit location.
5. Development of the distance to transit principle can be improved by creating activity centers within the area or integrate the activity centers outside the TOD area with emphasis on the destination accessibility principle. There should be a feeder system to connect the TOD location to existing nodes.

C. Urban Neighborhood Centers: TOD in Locations Dominated by Residential Areas

1. The density principle for residential areas with infill sites can be developed by building vertical housing, such as apartments, especially in the core area. Also, these vertical housings can be combined with other activities so that the diversity principle may be enhanced and compact development is obtained.
2. The diversity principle for residential areas means that the major land use is housing, but other activities should also exist to support the main environmental activity. Mixed land use is preferred, for example vertically for commercial and offices, so that the existing space is optimized for residential areas and public facilities. Other functions that may support the TOD area should be placed in the core area.
3. The design principle development should be focused on providing open spaces/parks that can be used for public activities and as interaction space. For parking, there can be secondary streets with on-street parallel parking in the core area so that the number of parking spaces can be controlled in the context of travel demand management. Park-and-ride would also help, since residential areas are mostly found in the countryside.
4. The destination accessibility principle development can be done by adding more options of transportation routes to support people mobility.
5. Because the distance between existing nodes and the TOD location is far, transit locations and feeders (planned and existing) should be integrated in the plan to connect the TOD area with existing nodes.

D. Special Use Centers: TOD Located in Locations with Special Use Characteristics

TOD in special use areas should be managed to support the specialty or main attraction of the area. The rest will be relatively similar to the aforementioned types of centers in accordance with the scope of service of the area, either regional, urban, or local.

7. Conclusion and Recommendations

TOD is suitable for urban areas that are characterized by high density, compact and mixed land use, possess efficient and high quality public mass transportation and an ideal pedestrian environment. The purpose of TOD is to centralize employment, housing, services and increase comfort levels around the major public transport facilities. Since TOD is about integrating transit (T) and development (D), a wholesale TOD policy and planning for a region must address two issues [13]: firstly, identifying areas where urban development has high transit orientation but poor access to high-quality transit, and secondly, identifying areas that surround high-quality transit but where the transit orientation needs improvement. To achieve these goals there are principles that must be fulfilled. This study adopted the 5D TOD principles (diversity, density, design, destination accessibility and distance to transit) as proposed by Ewing and Cervero [2].

TOD is an emerging concept in urban development in Indonesia, because some of the major Indonesian cities, including Jakarta and Bandung, are in the process of constructing urban railway systems. This study has developed a methodology to evaluate the feasibility of adopting TOD in built-up environments because there is a lack of guidance in this matter. Exercising this method is expected to ensure the effectiveness of TOD in the long run by considering the principles of TOD, existing conditions, spatial plans, and transportation plans.

This study specifically attempted to formulate a method that can be used for evaluating the conditions of a TOD plan area so that its development can be integrated and fitting. There are three main steps: (i) identifying the location characteristics based on criteria and indicators; (ii) formulating the problem structure at each location based on a gap analysis; and (iii) formulating recommendation guidelines for TOD. In identifying the location characteristics, there are some things to be highlighted. Firstly, the TOD typology needs to be determined as a basis for the development scale. The typology can be determined based on the local spatial planning policy as well as the local transportation development plan. Secondly, criteria and indicators are derived from the 5 TOD principles, although other concepts may be available.

Learning from the case studies divided into five typologies, different problem structures were found. The characteristics of each case are influenced by location, spatial policy, zoning regulations, and existing conditions (whether the location still has to be developed or not). In particular, areas in locations with special restrictions, such as flight operation safety regulations for an airport or other functions, the development of density and diversity may be restrained. In this context, the remaining 3 Ds (design, destination accessibility, and distance to transit) should be the focus of development and optimization.

If a planned TOD area is located in an urban or hub area, land use is dominated by commercial and service activities. At these locations, all 5 Ds can be developed optimally. The composition of diversity should be designed as attractive as possible, while the destination accessibility principle is also important because the TOD area at these locations must be easy to access from several locations both inside and outside the area.

For TOD locations dominated by residential areas, the 5 D principles can also be developed optimally. However, the diversity principle should be further observed; the diversity of land use in these TOD areas must be protected and developed such that it fulfills the needs of the local residents. Furthermore, residential areas must be connected well with transit hubs.

In conclusion, a methodology to assess the feasibility of TOD application in potential areas was developed by synthesizing a theoretical framework and empirical evidence. This method is expected to be adopted especially in the context of built-up environments, to assist the planning and development of TOD areas for which some principles should be followed without setting aside the characteristics of the existing area or spatial plans. The results can be applied for formulating more detailed guidelines on how to implement TOD, particularly in Indonesian cities. This study can also provide insight into the

complexity of TOD implementation in built-up environments from the perspective of integrating them in the spatial planning process, because it is problematic when TOD is not part of the paradigm of creating a sustainable urban form.

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