

# Assessing Transit Oriented Development (TOD) Elements at Earlier-Built Transit Stations

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## Abstract

Urban inaccessibility is part of urban transportation issues. TOD is a solution to promote accessibility, and land use planning is part of TOD principles. This paper shares the outcome of a study that focuses on the interrelationship of land use and TOD and evaluates the core areas of two earlier-built transit stations before TOD was put forward in Malaysia. Thematic analysis was employed together with site investigations, and results demonstrated the essential requirement of integrating land use planning in TOD and the performance of two transit stations which embrace some of the critical principles of TOD.

Keywords: Transit Oriented Development (TOD); Transit Station; Public Transportation; Rail-Based

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DOI: <https://doi.org/10.21834/aje-bs.v8i25.425>

## 1.0 Background

The Transit-Oriented Development (TOD) concept was initially developed by Calthorpe in 1993. Although there are many studies on TOD, the evaluation of TOD studies according to the many themes can be identified. Notably, while all rail-based station areas have the potential to be used for TOD implementation, the levels of accessibility vary from one rail-based station to another. Therefore, transit and land use planning should be done together (Vale et al., 2018). Through the investigation, the authors found various papers on constructing TOD models that concentrated on land use (Vale, 2015; Ma et al., 2018; Hasibuan et al., 2014; Sahu, 2018). In order to achieve sustainable growth in the local economy, ecology, and society, mixed-use development surrounding the TOD station area should be tailored to the local character, as mentioned by Niu et al. (2019). TOD aims to structure urban life's hubs around transit nodes (Yen et al., 2023; Ibraeva et al., 2020). TOD is allegedly associated with dense, mixed construction around transit nodes, incorporating residential, commercial or retail, offices, recreational, and public facilities (Chen et al., 2023; Yang & Pojani, 2017). Land use planning is a crucial component when designing TOD, which might influence TOD performance. The ideal TOD development design will enable inhabitants to easily and rapidly access a range of activities by walking or public transport without requiring a private vehicle (Duncan et al., 2021). Mathur and Gatdula (2023) believe that TOD can solve the consequences of urban sprawl. The definition of TOD is validated by a study by Kamal (2019), which stated that TOD includes walking-friendly, compact, high-density, mixed-use construction close to amenities and public transportation (Abdullah et al., 2022). While ensuring walking and cycling and livable neighbourhoods, it permits a mix of residential and commercial development and promotes accessibility for urban dwellers (Tsumita et al., 2023).

According to Hrelja, Olsson, Pettersson-Löfstedt, and Rye (2020), TOD is also defined as an approach to transportation and land use planning that maximises the efficiency of current public transit services by concentrating on development around public transit stations and stops while making walking, cycling, and transit use convenient and desirable. In addition, TOD is defined as "land use and transportation planning that maximises the efficiency of transportation services by concentrating urban development around transit stations" (Ibraeva et al., 2020). Beyond the definitions above, TOD can be viewed as a successful approach to achieving economic and environmental sustainability while lowering social exclusion (E. Papa, 2017). Planning for the economy and transportation can also help TOD be included in land use. According to Lynnon & Bray (2019), integrating TOD with land use planning can lead to happier, healthier, and more prosperous cities with less traffic congestion.

The TOD idea is mainly used in Malaysia to address the accessibility of the public transport system in urban areas, particularly Kuala Lumpur and the Klang Valley. Since 2005, the Malaysian government has emphasised this idea through the National Physical Plan. In order to ensure the viability of public transport, the policy declared that "Transit-Oriented Development shall be promoted as the basis for urban land use planning." By explicitly saying that TOD is one of the development concepts urged to be implemented in

the central urban region, the Malaysian government works to improve urban public transport through the plan outlined in the Third National Physical Plan (Department of Town and Country Planning, 2016). In addition to laws, the Department of Town and Country Planning has created a thorough guideline called Transit-Oriented Development. It was explicitly designed for TOD in Malaysia and contained all its fundamental components (Department of Town and Country Planning, 2018).

This study aims to investigate how land use planning and transit-oriented development (TOD) interact and suggest appropriate measures for application to become an ideal TOD. Most importantly, this study examines two transit station areas developed much earlier before the concept of TOD was imposed in Malaysia. In Malaysia, the notion of TOD was first put forward in 2005 by the government through its National Physical Plan. It has been mentioned again in the 2010 National Physical Plan (Azmi et al., 2021; Ministry of Urban Wellbeing, Housing and Local Government Malaysia, 2016). The study, therefore, relates to the idea that land use affects accessibility and movement efficiency and enhances people's mobility. The study also intends to analyse the idea and characteristics of TOD and assess the land-use standards for TOD effectiveness.

## **2.0 The Concept of TOD**

In Malaysia, urban inaccessibility is a continuing issue, and TOD is mentioned as an approach to resolving the issue. However, concerning TOD, there are several problems and difficulties. In order to address the issue of urban sprawl and growth, TOD is intended to encourage a new condensed development (Yen et al., 2023; Abdullah & Mazlan, 2016). The design and development of TOD must be carefully integrated with the land use surrounding its network to achieve a viable deployment. A perfect TOD should be practical, able to accommodate users in terms of walking distance, encourage comfort, and, most significantly, encourage people to take public transport rather than drive their cars. However, TOD has drawbacks. It is allegedly expensive to maintain, impacts the environment and human health, and raises land value in metropolitan areas (Saidan et al., 2021). Regarding the relationship between TOD and land use planning, choosing transit and land use separately may lead to inefficient land use optimisation. A further factor that discourages compactness, comfort, and walkability and promotes the use of private vehicles is zoning and land use limitations. Additionally, it is advised that transit corridors be planned from a regional viewpoint rather than merely at the local level because TOD includes transit routes that require collaboration between local and state governments (Saidan et al., 2021).

Most organisations and researchers from various nations and studies will outline the requirements based on the TOD principles. An integrated development's requirements (Rahmat et al., 2016) require a 10-minute walk around a major transportation hub. Density, design, and diversity all affect the requirements (Curtis et al., 2009). Six (6) key components, including a mix of uses, moderate to high density, pedestrian orientation or connection, transportation options, reduced parking, and high-quality design, are

characteristics of TOD (Lambert, 2014). In order to (i) improve access to the public transport network, (ii) provide public space to encourage a walkable environment, and (iii) develop high-density areas, the Queensland Department of Transport and Main Road (2021) prioritised the integration between effective land use and transportation. The United States Transit Oriented Development Institute (2020) emphasised three (3) concepts that should be thoroughly explained when designing for TOD regions, including (i) giving precedence to pedestrians; (ii) making places walkable; and (iii) ensuring that all needs are met nearby. Based on these, the following criteria must be taken into account: a 5- to 10-minute walk from the rail station to the nearby land use, public space, mixed-use activities in one area, a well-connected pedestrian and bicycle path, human-scale architecture, and active ground floor retail (United States National Association of City Transportation Officials, 2013).

The United Kingdom of Urban Transportation (2021) focuses on integrating quality transit in the hub of the development area. As a result, the indicators must be incorporated into any construction that includes high-density homes near public transportation and relies heavily on walking and bicycling for neighbourhood transportation (Linton & Bray, 2019). Similar to what Motieyan & Mesgari (2017) indicated, planners should pay attention to four (4) considerations when making plans: density, variety, area design, and social-economic development. While this happened, other researchers (Ewing et al., 2015) also noted related vital criteria, such as dense and mixed-use land, pedestrian-friendly neighbourhoods next to transit, and appropriate self-contained parking.

In order to define a TOD area, the Department of Town and Country Planning (2018) has outlined four (4) criteria in its specific Transit-Oriented Development Guideline, including (i) the transit shall act as an interchange station or transportation hub; (ii) the area must be a rail-transit station in the urban area or specialised area; (iii) an area free from the risk of natural disaster or pollution; and (iv) an area with existing or planned infrastructure (Department of Town and Country Planning, 2018). The REHDA Institute (2016) identified nine (9) traits that prioritise pedestrians by enhancing walkable design, completing the train station with a supporting transportation system as the prominent feature of the city, providing public space, a variety of land uses nearby, high-density buildings, cycling facilities, reducing parking areas, and providing accessible specialised retail at the transit station. Petaling Jaya City Council (2020) emphasises several criteria, including (i) mixed-use of activities and land use close to transit; (ii) high density or intensities of development to support the TOD; (iii) support transportation facilities in each development within the radius; (iv) safety features and comfortable surroundings; (v) pedestrian and cycling as the ideal modes of transportation; and (vi) public space as the focal point of community interactions.

Prior to designating specific land-use activities, land-use planning calls for assessment and decision-making (Cao, 2018). This study summarises the critical factors that should be included in TOD planning by reviewing a number of studies. According to the type of activity, land use can be classified as either agricultural, residential, vacated land, or built-up (Ullah & Mansourian, 2016). In addition, Ullah & Mansourian (2016) noted that the location of the closest community facilities could influence the usage of property for TOD.

Compactness, mixed-use activities, accessibility to urban amenities, and preservation of natural elements are similar ways to identify land use (Ostoji & Glaar, 2014). The Selangor Town and Country Planning Department (2010) lists additional requirements in addition to the ones listed above, including the proportions, plinth areas, plot ratio, gross floor areas, building intensities, design of the blocks and roads, building uses, landscaping, and provision of facilities.

According to Huang et al. (2021), the criteria to be taken into account while planning the site for TOD include optimising land usage, infusing the region with compactness, establishing commercial accessibility, and accentuating the variables that contribute to the passenger volume. The importance of compactness in the region was also highlighted by Huang et al. (2021) and Liu et al. (2020), who included high density as one of the land-use aspects. Other factors to take into account, according to Liu et al. (2020), are the diversity of the land distribution, site design, proximity to public transportation, and destination accessibility. Research conducted the same year by Liang et al. (2020) strongly emphasised circle-level development, walkability, accessibility to urban services, and the range of housing options. Prior studies have identified three (3) key factors that must be taken into account when planning land for transit development, including density, diversity, and distance (Sohu, 2018; Motieyan & Mogeswari, 2018; Singh, 2014; Jamal, 2011, and Curtis, Renne, & Bertolini, 2009). These factors are (i) density, (ii) diversity, and (iii) distance, which are the most crucial factors to be taken into account. However, Sohu (2018) emphasised that in addition to these three (3) key characteristics, the design of the surrounding region, accessibility to the intended destination, and demand management are all significant factors to consider. At the same time, Motieyan and Mogeswari (2018) emphasised that while distributing land use, economic concerns must be considered. Land use activities should effectively combine transportation components, facility services, and urban and economic growth, according to Taki & Maatouk (2018). Rahmat et al. (2016) listed key factors to consider when building property for transit: use, facility distribution, walking distance, parking availability, type of housing constructed nearby, and plot ratio.

Singh et al. (2014) also highlighted urban design components and considered the local economy. Jamal (2011) similarly underlined the amount of development or community, accessibility, and the kind of available transit. Berawi, Ibrahim, Gunawan, and Minaj (2019) highlighted the TOD features of density, diversity of land use, design, accessibility to destinations, and distance to transit as the benchmark for evaluating the integration of transportation and land use planning. A study by Shah, Abdullah, and Rashid (2020) illustrated how land uses planning and transit-oriented development are related. Based on land use and the Public Transportation Accessibility Index (LUPTAI), it tries to determine the quality of TOD stations. The goal is to gauge how simple it is to get by foot or public transport to frequent destinations (a variety of land use activities). The study discovered that commercial, residential, and mixed-use spaces dominated the land use pattern within 500 metres of the transport terminals in one of the larger cities in the Klang Valley region.

The combination of commercial, residential, and public services within the radius, according to Shah, Abdullah, and Rahid (2020), improves the level of ridership at the transit station.

According to a study by Yupho, Jomsueb, and Pujinda (2017), optimising the land near transit also enables the best mobility of people, commodities, or services between areas and boosts socio-economic gain. The researchers also emphasised the significance of sensible land use that considers the transit nexus. Additionally, a prior study by Nasrudin, Mohd Noor, and Abdullah (2018) found that people are not inclined to bike or stroll throughout the city. Instead of taking the bus or train, they like to use their own vehicle. Age, gender, and income level were among the variables that had an impact on this outcome. Regarding this study, usable land and transportation planning integration could assist and motivate the participants to use public transport and build an integrated, sustainable transportation system. Marzhuki, Omar, and Leh (2018) emphasised the difficulty of integrating the concept through strong governance support, a lack of coordination between the government and the land office, and the execution of associated regulations. TOD is one of the techniques for achieving sustainable development. Following the recommendation, land use planning and urban transportation will be integrated.

In order to achieve sustainability, Arifin & Zahari (2018) also emphasised the significance of walkability. By making the places more accessible to one another, TOD planning must take this factor into account. As a result, when building a space to promote a walkable environment inside the site, the planning must consider pedestrian ability and comfort. An efficient urban environment can support the development of the TOD region by adjusting TOD characteristics to relevant land activities. From several angles, Sham, Hussein, and Ismail (2018) emphasised the safety factors when using public transit concerning urban environmental design. The researchers stressed the importance of the urban setting and infrastructure, particularly for transport users. The element to address these problems is typically infused with the TOD feature. Therefore, combining all necessary land use activities in one location improves the urban environment.

### **3.0 Methodology**

This section will describe the work process and approaches accordingly. This study involved two stages of exercise.

#### **3.1 The Thematic Analysis**

The first stage was to obtain data from previous studies and scholars demonstrating the integration between land use and transit planning. The analysis employed the Thematic Analysis by applying Scoping Techniques to identify research trends on the subject matter. This method aims to identify the themes like the data pattern required to address the research matters (Maguire & Delahunt, 2017). Thus, this study needs to know how to define Transit-Oriented Development's character. Henceforth, scoping reviews are suitable

techniques to investigate a broad area and topic trends (Grant & Booth, 2009), especially in defining the land use characteristic suits for TOD.

The application of the method mainly referred to Arksey and O'Malley (2007). However, the process employed for this study was adapted from Westphal et al. (2021) since the researchers have enhanced the previous method. Figure 1 below shows the scoping review process adapted from Westphal et al. (2021) used for this study. The researchers first searched articles using the keywords "Transit-oriented Development" to gather the related literature. The study obtained a thousand and twenty-one (1,021) indexed and non-indexed articles using the keywords. From there, the researchers had to study the content of those articles to retrieve and capture similar studies to this study. They obtained four hundred and forty (440) articles that mentioned TOD and related land use. During this time, the researchers used "Transit-oriented Development" and "Land use Planning" as the keywords. Any articles that present TOD without the subject of land use or vice versa will be eliminated. This procedure left the articles to seventy-three (73) pieces. After that, the study narrowed down the search to different keywords, i.e., "Characteristics of TOD" and "Criteria of TOD", also "Parameters of TOD" and "Indicators of TOD". Finally, after scheming through the articles and exploring the content, the researchers reduced the articles to twenty-seven (27) works of literature that relate primarily to the study, concentrates not only on TOD and land use but also on the criteria of land use development for transit-oriented development. The data collected were then thematically categorised into priorities starting from the characteristic of the transit-oriented development into the land use criteria that suit the concept. Finally, the subject required the equations for land use planning in the transit-oriented area. It was extracted by identifying the keywords from the most extensive scope into specific subject matters. The criteria of TOD show similar indicators to the principles used in designing the transit development. Land use also required specific enhancement while configuring the area in other parts.

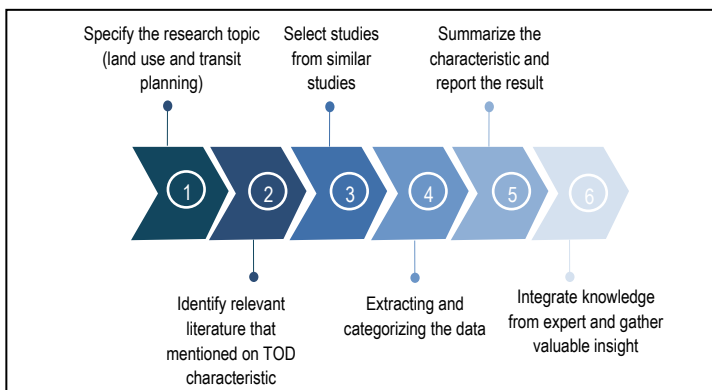


Figure 1: Method of study  
(Source: Westphal et. al, 2021)

### 3.2 Site Investigation

The second stage involved site investigations surrounding the areas of two transit stations built before the TOD concept was introduced in Malaysia. Subang Jaya Commuter Station and Tun Sambathan Monorail Station were employed as case studies for this task. The purpose was to examine the existence of TOD principles at both stations despite the non-application of the TOD concept during the development of both transit stations.

Subang Jaya Commuter Station began its operation in 1995, even though the early spatial development of Subang Jaya started in 1974. The initial idea was to create a new township within the Klang Valley, changing the landscape from rubber plantation to housing and commercial area by Sime UEP Properties Berhad. Nevertheless, the railway was built in 1886 to meet the demand for transportation from Kuala Lumpur to Klang. Meanwhile, spatial arrangement for the Tun Sambathan area appeared during the British occupation, which saw the British bringing the Indians to build the railway. Thus, the area surrounding Tun Sambathan experienced a more extended development period. The Tun Sambathan Monorail Station started its operation in 2003. Based on the development period for both transit stations, the areas are now considerably saturated with development.

To understand the existence of TOD principles and criteria in both areas, the study demarcated the boundary for study. Both areas were examined within the range of 400 metres from the transit stations. This approach was taken with the perimeter of core areas for TOD outlined in the Malaysia TOD Guideline (Department of Town and Country Planning, 2018). The Malaysia TOD Guideline was referred to since the guiding principle accounts for the local context and urban setting. The guideline suggested that the main peripherals of the transit stations be called *Transit Influence Zone*, which should encompass economic activities, administration, employment, housing, and culture (Figure 2).

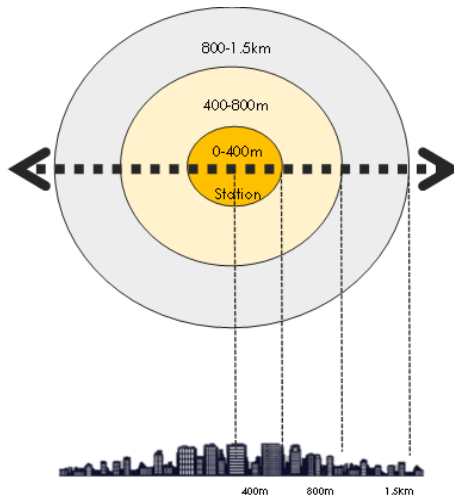


Figure 2: The boundary of the study area embraces the 400m radius  
(Source: Department of Town and Country Planning, 2018)



## 4.0 Results and Findings

The following discussions convey the findings in two primary components of the analysis. The first part elaborates on the outcome of the thematic analysis carried out from the secondary data. For the first part, this research summarises two (2) main findings from the literature regarding the interrelationship between land use and transit-oriented development (Section 4.1) and the main criteria of land use that is compulsory in each TOD (Section 4.2). The second component describes the evidence of mixed-use activities in the two study areas (Section 4.3).

### 4.1 Interrelation between land use and TOD

Transit-Oriented development focuses on land use planning that is integrated or located with public transportation hub or station, either a rail-based system or the rapid bus system. Through the definitions, the importance of proper land use planning cannot be denied due to its impact on certain areas targeted for transit purposes and act as one of the sustainable urban land use planning approaches (Ruan, 2021). The dissemination of land use influences the concentration of development in or around a transit station (Mishra & Mishra, 2021). Otherwise, land use planning is one of the land administration and management functions to obtain sustainable development (Shrestha et al., 2021). Similarly, Liang et al. (2020) also stress integrating land use with TOD to achieve sustainability. Merging the rail-transit system with surrounding land use can comprehensively solve transportation and urban development issues (Huang et al., 2021).

TOD and land are usually integrated to encourage public and non-motorised transportation modes and alleviate the pollution caused by car dependency (Abdi, 2021). According to Berawi et al. (2019), the suitable proportions for land planning in TOD areas are designated as 46% for residential purposes, 18% for offices, 23-26% for commercials such as hotels and retail, and 12-13% for other land use type because the proportion will allow more properties to be developed in one area. The essential parts of the development, such as compactness and mixed-used activities, will influence the allocation or distribution of land use within the transit-oriented development radius. TOD will organise settlements around transit nodes as centres of urban life (Ibraeva et al., 2020) since it involves intense, mixed development around transit nodes (Yang & Pojani, 2017) and allows a mix of residential and commercial (Kamal, 2019). According to this study, rail-based transport systems and land use should be integrated into TOD planning to enhance the suitability of rail transit, efficient land use, and the effectiveness of traffic operations (Ding et al., 2017; et al., 2018). Sahu (2014) indicates the relevance of land uses for TOD, in which land use can be changed to fit the TOD concept, and integration between two of these will affect each other since both are linked together coherently. Department of Town and Country Planning (2016) justifies an approach to land use solution by emphasising accessibility enhancement, compacting the urban form, and allowing mixed-used development within 800 metres and the core activities within 400 metres from the transit station. These matters were all associated with forming plans for the area and planning documents for the local

authorities. Figure 3 below shows the network mapping of the interrelation between land use planning and TOD.

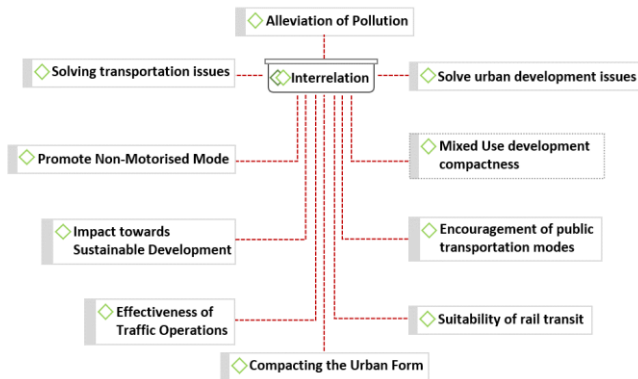


Figure 3: Mapping of interrelation between land use planning and TOD

#### 4.2 Main criteria for land use and TOD

The first criterion is TOD's type of land use or land use diversities. Through several works of literature, the study found that the various kind of activities in an area is the main attribute to be offered while allocating the land for transit development purpose (Jamal, 2011; Singh et al.,2014; Rahmat et al.,2016; Motieyan & Mogeswari, 2018; Sohu, 2018; Liang et al.,2020; Liu et al.,2020, and Huang et al.,2021). Sahu (2018) recommends increasing the diversity of land use for daily needs such as supermarkets, laundry, retail shops, restaurants, and other services. Furthermore, it was suggested that making a certain mix percentage is necessary for development around the radius area. Motieyan & Mogeswari (2018) also stated that measuring the land use mixture or percentage of each land use type is essential. Taki & Maatouk (2018) pointed out that the integration to make diverse land use types must include the transit station, transport support facilities, residential, and facilities services such as schools, hospitals, recreation, and other community facilities. A study by Liang et al. (2020) claimed that land use must be integrated to achieve land use efficiency and social equity (for example, land use activities and provision of housing types). Huang et al. (2021) indicated that TOD planning would succeed by integrating rail transit stations and commercial, residential, and public land use. Liang et al. (2020) clarify that providing different activities will increase access to urban facilities. Based on the evaluation established by Taki & Maatouk (2018), it can be concluded that the most suitable land for TOD must include more than 80% of building coverage, and 2-9% of the land use is a park. Meanwhile, the ratio for planned housing is between 1.2-2.3. The residential area is

between 1.9-4.6, and the ratio for industrial (>4.7), commercial (>0.3), and residential (>6.9).

The second criterion is compactness or density. The study also found that the second aspect to be prioritised in designing the land is the level of compactness or density in the area (Jamal, 2011, Singh et al.,2014; Rahmat et al.,2016; Motieyan & Mogeswari, 2018, Sohu, 2018, Liang et al.,2020, Liu et al.,2020, and Huang et al.,2021). Jamal (2011) mentioned that the residential around the transit station must be considered, whether it will be a high-density area; thus, multi-storey residential types or high-rise units are the primary concern. Furthermore, the researchers added that the development must fulfil the minimum density required. Singh et al. (2014) and Motieyan & Mogeswari (2018) highlighted that density must be incorporated into all land use types, including commercial, employment, administrative, or residential buildings. Sahu (2018) clarifies that the planning must minimise land use change and make land uses more compact to achieve human development scale. Meanwhile, Liu, Zhang & Xu (2021) elaborated that the density can be measured by quantifying the concentration or intensity of activities per area unit (measured by the number of people and jobs per acre, dwelling units per acre, or building floor-area ratio). Taki & Maatouk (2018) calculated that the suitable population density is more than 28,000 people. In addition, the equation made from the study conducted by Zulkifli (2017) categorises low density as (0-400 units/hectare), medium density (401-700 units/hectare), and high density (701-and above).

The third is the accessibility, connectivity, walkability level, or proximity. The parameter to be emphasised is regarding on the distance between one land use type to another land use type (for example, the accessibility from the residential area to the commercial area) (Jamal, 2011; Singh et al.,2014; Rahmat et al., 2016; Motieyan & Mogeswari, 2018; Sohu, 2018, Liang et al., 2020, Liu et al., 2020, and Huang et al., 2021). Sahu (2018), in his study, highlighted a recommendation to increase residential and commercial near the stations. Huang et al. (2021) stated that accessibility within the land cells is the most vital part to be measured. In addition, the study also stressed the best way or land use plan based on the quantity, location, and density of each land use type cell in the station area. Liu et al. (2020) use measurement in creating the area by emphasising street network, transit station and route, distance to the transit with the time required, and destination accessibility supported by facilities and environment offered in that area. Liang et al. (2020) mentioned the importance of establishing a good TOD radius zone to increase walkability. Also, Motieyan & Mogeswari (2018) elucidated that the design of the street will determine the connectivity between land areas.

Additionally, Rahmat et al. emphasised the distribution of surrounding land use within the radius of each TOD zone to ensure the provision is within the radius and enhance access to all facilities. These studies concluded that the distance from the basic community facilities must be 250 meters from the station. Table 1 shows the land use criteria required for TOD that were agreed upon by many scholars from the analysis of the related 27 articles.

Table 1: Land use criteria required for TOD

Author Keyword/ Subject	Total Number of Publications	Percentage (%)	Rank
Types of land use Land use diversities	10	37.04	1
Compactness Density	9	33.33	2
Accessibility Connectivity Walkability Proximity	8	29.63	3
N= 27		100	

The data collected from the reviews showed that early studies focused more on TODs in general by exploring the distinctive of each TOD typology. Nonetheless, it was found that TOD was defined using specific aspects, thus establishing the TOD characteristic accordingly. Moreover, the findings indicated similarities between the TOD design principles with the characteristics established by various agencies or researchers. Several recent studies also showed that the topic was extended to incorporate transit into land use planning. This study can then categorise all the characteristics into detailed land use elements to be considered in TOD planning through previous studies. However, the findings also contradict several characteristics distributed in different terminologies due to the repetitiveness of the essential requirement for land use planning for TOD.

Meanwhile, various reviews also found that TOD will succeed if the land use distribution or allocation can be effectively integrated, hence allowing more benefits for the area. It is strongly suggested that prioritising compliance with the main criteria in creating TOD will encourage effective land use around the transit nodes, especially allowing a mixture of land use types. TOD is one of the approaches to creating a more sustainable urban environment; therefore, planning for TOD by complying with all the matters to achieve diverse, high intensities and the walkable area is essential for better living conditions.

#### 4.3 The existence of TOD measures in study areas

The site investigations at both Subang Jaya Commuter Station and Tun Sambathan Monorail Station revealed that some elements of TOD existed in both areas. As mentioned earlier, the appraisals only involved the core areas of the transit stations (within a 400-metre radius), and both stations were not initially planned according to the TOD principles. Therefore, the existence of all principles of TOD needs to be more comprehensive. The density of the land uses results from the long development experience, yet both areas showed differences in land use components. Results demonstrated that both core areas focused on the residential and commercial, with Tun Sambathan highly occupied by commercial activities (Table 2). However, even though both areas have housing, Tun Sambathan only has low-cost apartments while Subang Jaya showed a mixture of clusters, terraced and apartments. Only that, within the 400m territory, Subang Jaya transit station does not offer low-cost houses.

Table 2: Land use components in core areas

Land Use Components		Subang Jaya Commuter Station	Tun Sambathan Monorail Station
		400m radius	400m radius
Housing	Bungalow	X	X
	Cluster	/	X
	Terrace	/	X
	Apartment	/	/
Type of Housing	Low cost	X	/
	Medium cost	/	X
	High cost	/	X
Commercial	Retail	/	/
	Private services	/	/
	Professional services	/	/
	Shopping centre	/	X
Administrative Institution	Administrative	X	X
Public Facilities	Education	X	/
	Health	X	X
	Safety / Emergency	X	X
	Religious	X	/
	Community Hall	X	X
	Recreation	/	/
	Outdoor Public Space	X	/
	Bicycle Lanes	X	/
	Pedestrian Pathways	/	/
Pedestrian Bridge	/	/	

Note:  / Exist  x Non-Existent

Based on Table 2 above, the study captured some crucial elements of TOD, as suggested by the guideline in both areas. Both core areas have residential, commercial, and public facilities. Nevertheless, none has administrative buildings, as suggested by the guideline within the Transit Influence Zone. Although Subang Jaya core has more variety of housing types, the area still needs low-cost housing. Meanwhile, in terms of public facilities, the Tun Sambathan core area consists of more public facilities than the Subang Jaya core area. Nevertheless, both core areas have many commercial types, but the Subang Jaya core area contains a shopping mall. The land use composition may be partially mixed-use but, to some extent, incorporates a compact spatial arrangement. To understand the compliance of TOD criteria for both core areas, the following discussion presents the verdict.

## 5.0 Discussion

The study revealed that the cause of road congestion results from the high volume of private vehicles on the road. However, this is inevitable because people tend to choose their vehicle as their mode of transport due to the ineffective service of public transport and the placement of TOD with land use. This behaviour cannot be avoided since the public

believes using their vehicles will make them reach their destination faster and, most importantly, more accessible. Some transit stations require people to commute to the station by feeder bus or their vehicle to continue their journey on the rail. This will increase their travelling time and more hassle. Therefore, it is imperative to avoid the disconnection of land use with the location of transit stations. Integrating land use with TOD planning may change the public's behaviour in accepting public transport as the primary mode of travel. Thus, this attitude shift will not affect their mobility, travelling time, and level of accessibility. Also, based on the literature, the study found that the previous studies did mention the characteristic of Transit Oriented Development (TOD). However, only a few studies focus on the specific criteria for land use, especially in designing rail-based transit-oriented development.

Land use planning is essential for any TOD area. Land use diversity is claimed as influential for an effective TOD. Motorised vehicles can be discouraged within the core areas if land use is adequately designed and distributed without compromising the variety of activities like living, working, and recreational activities. Some scholars admit that the integration of land use planning and TOD may promote the area's sustainability, especially when walkability is infused into the design of land use. In fact, some scholars agree that TOD and its interrelationship with land use can solve urban transportation issues and reduce traffic congestion by encouraging non-motorised transportation modes. Otherwise, the compactness and mixed-use activities suggest the efficacy of TOD. Besides compactness, density, and mixed-use activities, scholars also recommended a diversity of land uses for daily needs and activities. Commercial activities should offer a variety of businesses to cater to the needs of the public, including retails, supermarkets, restaurants, and other services.

Subang Jaya Commuter Station and Tun Sambathan Monorail Station possessed mixed-use elements concerning the abovementioned criteria. However, not comprehensive and encompassing commercial activities, but Subang Jaya offers a better variety of commercial types. Both core areas are compact with residential, employment, commercial and recreational, and both areas provide job opportunities. Regarding the findings from the thematic analysis, which suggested that density is another key aspect of TOD, both areas are seen as saturated with development. They are high-density due to the existence of many houses.

Apart from land use, mixed-use, and density, the analysis revealed that accessibility, connectivity, and walkability also contribute to an ideal TOD. However, the distance from one building to another and from the residential areas to the transit station is considered necessary, whereby the location of land uses is suggested to be close, preferably by walking. This criterion was detected in the core areas for both transit stations. The findings (Table 2 above) identified that there are also facilities to support walkability and to motivate the use of non-motorised vehicles, through which the provision of bicycle lanes and pedestrian paths, as well as pedestrian bridges. Only the Subang Jaya core area needs bicycle lanes, indicating a need to study the demand for bicycle lanes further. In other respects, both core areas showed that accessibility and walkability prevail within the area.

Nonetheless, it is hard to say whether connectivity exists within the area, as it requires a detailed analysis of connectivity and public perception. This is because the land uses for both areas were prearranged before the concept of TOD.

Thus, based on the findings from the study, the two transit stations built before the TOD was instilled in Malaysia do feature some TOD principles, even though not comprehensive. Mixed-use activities surround both transit stations, and the provision of public facilities supports the areas. The walkability element is evident, but cyclist facilities should be paid attention to, especially in the Subang Jaya core area. Both transit stations function partially according to the Malaysia TOD guideline because not all indicators were detected as outlined.

## **6.0 Conclusion**

This paper summarises the interrelation between land use planning with Transit-Oriented Development (TOD) and three (3) primary characteristics of land use planning for a TOD area. The results demonstrated that priority must be given to offering the land-use activities in the area, including the mixture of each land-use type supported by various facilities allowing the end-users or residents to obtain urban services quickly. Secondly, having all the activities centred in an area will encourage the next priority toward creating a compact, high-density area. Lastly, it is crucial to ensure all the land uses can be easily accessible and incorporate elements that encourage walkable neighbourhoods or cities where transit is the centre of the development of that area. Therefore, the study recommends that any new TOD development consider the three (3) essential criteria for land use planning to integrate with TOD development, as these elements were primarily discovered as the most significant aspects of land use planning for TOD. Since land use planning is often conducted at a local level, the approach to practice must be changed. Local authorities should coordinate with the state or federal government to look at the planning aspect at a regional level, not just at a local level. This will ensure that the transit corridor will integrate with the land uses, thus achieving the efficacy of TOD functionality. Also, the investigations at the two transit stations and the surrounding 400 m territory revealed that earlier-built transit stations possess some of the key characteristics of TOD. Suppose the revitalisation of those areas is carefully planned. In that case, more TOD criteria can be infused into redevelopment, thus creating a TOD area even for old transit stations like Subang Jaya Commuter Station and Tun Sambathan Monorail Station.

## **Acknowledgement**

The authors would like to acknowledge Universiti Teknologi Mara (UiTM) for funding this research under the Special Research Grant (600-RMC/GPK 5/3 (057/2020)), and to thank the Research Management Centre (RMC) and the College of Built Environment for supporting the research.

## Article Contribution to Related Field of Study

Transit Oriented Development (TOD) is a newly ventured concept in Malaysia even though the idea originated in 1993. To date, it is difficult to claim that the new transit stations built in Malaysia are comprehensively TOD practice. But it is never wrong to infuse the idea of TOD into transit stations that were built before the concept became popular in the country. Perhaps, the urban settings and composition of land use of transit stations built earlier can adapt and become an ideal TOD. This study may provide some propositions for remodelling the areas surrounding the existing transit stations as TOD. If not totally transformed into TOD, to some extent embodies the principles of TOD and thus brings positive impacts to rail-based public transportation.

## Authors Declaration

This article is an extended version of the original conference paper published in the E-BPJ, Vol (7), No. 20, June 2022, 397-405.

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