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Planning TOD with land use and transport integration: a review

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Abstract

Transit Oriented Development (TOD) implementation in urban development is globally adopted by many countries in the world in a rapid manner. However, the city and regional acute problems is still propagating. An in-depth study to examine this problem is required. Thus, this paper review various study related to the integration of land use and transport with TOD. The subject of the paper will be described as follow: Method, criteria and indicators of TOD'S research, Reviewing the strategic plan and the public transport plan in the worldwide, and Cross-continent comparison of integration planning. In conclusion, practice and integration of TOD through land use and transportation is an alternative solution in acquiring the objective of the master plan and to solve urban issues such as urban congestion, reduce travel time, and car dependency.

Keywords: Planning, Transit Oriented Development (TOD), Transport, Land use, Integration

1. Introduction

Transit-oriented development (TOD) is a notion-oriented city-region development to provide maximum access to passengers (Curtis & Scheurer, 2010; Hasibuan & Soemardi, 2014), especially public transport such as trains and bus with the purpose of the creation of comfortable atmosphere with friendly environment and are equipped with various facilities such as parking, parks, offices, and more, this requires a mix of residential and commercial areas of the compact and the mixture to facilitate become a base for the development of public transport transit area-based (Cervero & Dai 2014).

TOD, in general, is the part of the public transport system (Black et al. 2016). The positive results of TOD was obtained by a city include: creating a healthy environment due to the declining number of pollution (Dou et al. 2016), the city's economic efficiency due to the increasingly large amounts of transportation costs and speed the travel time (Li et al. 2013), the creation of the city transportation system efficiency because of the many passengers who switch from private cars topublic vehicles and reduced congestion (Boschmann & Brady 2013), and land use had inflicted because of area around the station settings appropriate allocation that is compact and mixed (Ratner & Goetz 2013).

1.1 Urban Planning and TOD

The concept of TOD is very closely related to urban planning because it is a derivation from the movement of The Garden City Movement was popularized by Ebenezer Howard in the late 19th century (Black et al. 2016). Howard called on to decentralize the cities too dense. The concept now known as classic town plans are characterized by a pattern of radial road pattern grid which converges on a focal point or in town centers. The master plan includes the urban garden, and put forward the use of the public (Arrington & Cervero 2008). The road is designed to achieve a balance between pedestrian and vehicular, accommodate trees, sidewalks, and street furnishing while also providing visibility and ride comfort and on-street parking. The buildings directly facing made to roads with features that create the excitement of public spaces.

A TOD generally have an embodiment in the form of the commercial core with the distance reached by residents, a grid-shaped road network well connected, the width of the road that are not too large with parking on a side street as a buffer for the pedestrian, a back-lot alley, land use mixed-residential use, with different types of density (Dorsey & Mulder 2013). The area resembles the traditional community form TOD with unique characteristics and different where the transit station and its surrounding areas became the focal point (Ulloa 2011).

1.2 Integration land use and transport using TOD concept

Transit Oriented Development is a part of urban development with emphasis on a growth point to minimize the occurrence of sprawl (Zhang 2008). Through the concept of TOD, a city developed at some points grow, which is the point of rest mass transportation. Consequently, there is the division point of growth based on the route to public transportation stops (Xie & Levinson 2009). This concept is also a regional design that makes up an accessibility network in regional scale and it becomes an integrated union. The unity was formed through an integrated transport network and land use that creates a territorial integration (Wieberneit 2007).

The station area was developed by integrated TOD and pedestrian-oriented creates an environment with convenient, secure, fun and sufficient for the pedestrian walkable environment) (Wey & Chiu 2013). The mixture of various function's activities generates a shorter trip and quickly. These functions are the land use includes commercial area center, offices, retail, services, and localities with a population density of medium to high density and public open space (Wey 2015). In thetransportation point of view,TOD involved the inhabitants in the everyday interaction and reduce auto-oriented activities. Inhabitants who have limitations in the use of private vehicles (due to economic reasons, the age of children or the elderly) still had access to many facilities and meet his needs (Vos et al. 2014).

1.3 The research problem

Urban transportation activities have a significant effect on the increase of traffic congestion and air pollution. There are solutions that have been implemented, but still limited to practical approaches. Furthermore, the problems of urban transport need to be reviewed through a systemic approach, namely, the establishment of the urban transport system in a macro integrates aspects of land use and transportation. The current paradigm of the cities in the world in addressing the problems is by starting to implement innovative strategies through the application of the integration system concepts. One of them is the concept of Transit Oriented Development (TOD).

1.4 The objectives of research

The objective of this paper is to encourage application of TOD as one of the alternative solutions in addressing the problems of congestion and pollution of the city through the integration between the transport nodes with land use in adjecent of the station. This paper emphasizes the study of linkages characteristics-based TOD transit area to encourage movement of ridership using mass transit.

2. The methods

This paper provides evidence of integration between transport and land use with TOD from literature by formulating a long list indicators of the district-based TOD through study literature regarding TOD practices in cities in the world. The formulation of the protracted lists is done by a qualitative descriptive analysis technique through the theoretic approach to the concept of TOD. The formulation of the protracted lists, which is performed to confirm suitability indicator concepts for the TOD was adapted in the local context. The stakeholders are the key to understanding the characteristics of the area and transportation. Formulation of criteria-based TOD area is obtained using descriptive method and comparative analysis between existing conditions of the area with TOD indicator that has been deduced from the study of literature.

3. Result and discussion

3.1 Planning and assessment of TOD research in the last 5 years covermethods, criteria and indicators.

Efforts to develop a TOD research has been discussed in some study and continue to grow in accordance with developments in the public transport sector. This section discuss some of the studies (See Table 1).

A study by Atkinson-Palombo & Kuby (2011) about TOD discusses TOD typologies, several stations classified based on the type of overlay zoning, the method used was factor analysis and cluster analysis with the result that is ranking from low to high advance TOD each station, although data based on multi-criteria but in separate discussions and after that created relationship between LRT and TOD.

Prasertsubpakij & Nitivattananon (2012) measured metro station in Bangkok metropolis, Thailand by measuring TOD access, various values of some variable research made the comparison using the accessibility score, T-test, and t-significant values. Data collection was obtained from questionnaire with approximately 600 respondents.

Binglei & Chuan (2013) measured the TOD mode analysis with DEA (data envelopment analysis) mathematical formula using software. This study obtained the ranking by making evaluation of actual TOD with land use and urban rail transit as variables.

In his study, FARD (2013) found the TOD index using SMCA (spatial multi-criteria analysis) i.e. counting criteria and indicator of spatial data, the results obtained are TOD level based on the potential area for construction of the new station. His study is equipped with hot-spot analysis techniques to observe potential differences between areas.

Ratner & Goetz (2013) divided type of TOD based on urban structure and land use, the study elaborated data of land use and urban form in the

comparison of Denver area. The results are the typology and its impact on the development of Denver city, the study emphasize on descriptive variables and describing the relationships between variables.

TOD typologies were introduced by Kamruzzaman & Baker (2014) i.e. categorizing each TOD based on cluster analysis and node place typology. The multinomial logistic regression is applied as statistical analysis to obtain TOD cluster. TOD level is not very clearly presented in the final value yet elaborated based on the typology of each station, where the variable based on typology research is taken.

Study of Singh (2015) which discussed TOD composite study stated TOD index findings using weighted method from each of the criteria indicators followed by the assessment of each station based on the gained index, the study orientation is in Stenberg, Netherlands, using multi-criteria analysis using ArcGIS and ILWISS software to produce TOD score map.

Papa & Bertolini (2015) compared the value of TOD between 6 metropolitan areas in Europe, the study using node-place model with various indicator TOD and rail-based accessibility. The study observe existing area of the metropolitan with the result that accessibility is higher in urban areas.

Table 1.
Method, criteriaand indicators of TOD research

study/paper	Method	criteria	indicator	measurement/description
(ATKINSON-PALOMBO & KUBY 2011)	Factor analysis and cluster analysis overlay zoning	Social and demographic characteristics	Numbers of jobs Population Pet of people with Bachelor's degree Household income Pet of housing units-owner occupied	
		Transportation-related characteristics	Park-and-Ride Airport Terminal	
		Percentage of land-use in each station area (%)	Residential Vacant TOD-compatible TOD-incompatible	
(Prasertsubpakij & Nitivattananon 2012)	Factor analysis and reliability test. Indicator assessment of metro accessibility	Psychosocial (Y1)	Safety Social usefulness Trust Comfort	Sufficient level of commitment of safety operation and strategies of managers/ staff The extent to which attitudes on positive feelings of users on metro services on perceived support (respect, recognition, approval) The extent to which attitudes of willingness to rely on metro services Satisfaction level of people on cleanliness, lighting, weather, ventilation, shade, etc.
		Temporal (Y2)	Activity period Trip purpose Duration	Time period of target activities The characteristics of trip purposes The comparison of duration preference of metro trip e.g., trips on daytime, on-peak, off-peak
		Affordability (Y3)	Income Occupation	Personal income per month (THB per month) Occupation of respondents
		Basic needs and market-based (Y4)	Basic needs Market-based	Attitude level on how metro services respond to their needs and desires Attitude level in response to "Do you get what you pay for?"
		Connectivity and mixed use (Y5)	Potential connectivity Mixed use	The calculation of average connectivity and average integration by space syntax technique $1-\left\{\frac{\lvert r-\frac{1}{4}\rvert+\lvert c-\frac{1}{4}\rvert+\lvert i-\frac{1}{4}\rvert+\lvert o-\frac{1}{4}\rvert}{1.5}\right\}$ Where: r=acres in residential use (single and multi-family housing), c=acres in commercial use, i=acres in industrial use, o=acres in other land uses, and T=r+c+i+o. A value of 1 indicates perfect mixing of the four land uses
		Design attractiveness (Y6)	Attractiveness of metro utilities	Percentage of weighted attractiveness summations of utility design (built-environment around stations) adopted to optimize Metro the use of metro services
		Equity (Y7)	Equality to access Opportunity to access	The extent of attitude to which respondents think that they receive equal benefit from services The extent of attitude to which respondents think that they have equal opportunity to access metro services and are taken into account in an equal manner
		Time and activity obligation (Y8)	Time obtaining Activity location	Total time (min) The distance of activity locations from stations (km)
		Urban environment/ compact (Y9)	Compact Reducing sprawl	Percentage of residential, commercial, employment and other activities near the station within a 5 km radius Level of attitudes related to spatial knowledge and settlement, modal experiences, paths and behavior to reducing sprawl quantify

(FARD 2013)	hot-spot analysis SMCA (spatial multi criteria analysis)	Level of density	Residential-density Commercial-density	Higher residential and commercial densities are required for more efficient public transport
		Level of land use- diversity	Land use diversity	Higher diversity of land uses reduces vehicular trips and enhances the liveliness and safety of a place where people socialize
		Level of mixed use	Mixed use	Higher mixed-ness of land uses (w.r.t residential land use) encourages higher degree of walk and cycle for non-work trips
		Level of economic-development	Number of business-establishments	The higher number of business establishments represents higher level of economic development and hence higher TOD levels
(Binglei & Chuan 2013)	DEA projection DEA (data envelopment analysis)	Urban rail transit	Convenient path from home to transit station in TOD community	Average time from houses to stations (min)
			Efficient transfer between rail transit and buses	Average transfer time (min)
			No waste of public transport resources and passengers should not exceed the capacity of transit station	Utilization rate of the transit station capacity (%)
			Encourage public transit ridership	Split ratio of bus trips (%)
			Reduce emissions from cars to protect the environment	Vehicle kilometers travelled per capita (km per capita)
			Reduce unnecessary trips to control the total traffic demand	Trip distance per capita (km per capita)
		Land use	Make full use of land resources to prevent low density spread	Population density (people per square kilometer)
			Employment-Housing balance	Employment-housing ratio (%)
			High density development	FAR (floor area ratio)
			Comfortable environment for walking and using bicycle	Non-motor lane area ratio (%)
			Mixed land use incorporating different land use functions	Non-residential land use area ratio (%)
(Kamruzzaman & Baker 2014)	cluster analysis, node place typology multinomial logistic	Density	net employment density	the number of jobs located within a unit area of employment generating land uses (e.g. commercial, industrial) located within a CCD (e.g. number of jobs/hectares)
			net residential density	the number of residential units located within a unit area of residential zoned land (e.g. unit/hectares) within the buffer of each CCD
		Diversity	land use diversity	the following formula of Simpson's diversity index in which the higher value represents more diversity of land uses (value ranges from 0 to 1)
		Design	intersection density	the number of 3 or more way intersections located within a unit area of the buffer for each CCD (e.g. number/hectares)
			cul-de-sac density	the number of dead ends located within a unit area of the buffer (e.g. number/hectares)
	regression analysis		public transport accessibility	Closeness to public transport Ease of walking to places Wanted to live close to shops Closeness to open space (e.g. parks) Near to green-space or bush land Closeness to schools Closeness to childcare Closeness to the city Closeness to work Access to freeways or main roads %
(Singh 2015)	weighted analysis	Density	Population density Commercial density	Population density (persons / sqkm) Commercial density (number of commercial enterprises/sqkm)
		Land use diversity	Land use diversity	Land use diversity creates a vibrant/ lively place out of a node
		Walkability and Cyclability	Mixedness of Cyclability residential land use with other land uses	Mixed-ness of residential land use with other land uses
			Total length of walkable/cyclable paths	Total length of walkable/cyclable paths (meters)
			Intersection density	Number of intersections/sqkm)
			Impedance Pedestrian catchment area (IPCA)	Impedance Pedestrian catchment area (IPCA)
		Economic development	Density of business establishments	Number of business establishments/sqkm
		Capacity utilization transit	Passenger load in peak hours	Passenger load at peak hours
			Passenger load in off-peak hours	Passenger load at off-peak hours
		User-friendliness of transit system	Safety of commuters at the transit stop	Safety of commuters at the transit stop
			Information display systems	Basic Amenities at the station Presence of Information display systems (Yes/no)
		Access to and from the station	Frequency of transit service	Frequency of transit service (number of trains operating / hour)
			Interchange to different routes of same transit	Interchange to different routes of same transit (number of routes)
			Interchange to other transit modes	Interchange to other transit modes
			Access to opportunities within walkable distance from train station	Access to opportunities within walkable distance from train station (number of jobs)
		Parking supply at the station.	Parking supply-demand for cars/four wheelers	Parking supply-demand for cars/four wheelers
			Parking supply-demand for cycles	Parking supply-demand for cycles
(Papa & Bertolini 2015)	bivariate and correlation node-place model	The place index	Structural land use	Study area (km2) Inhabitants and jobs (inh. + jobs) Average population and jobs density ((inh. + jobs)/km2)
		The node index	Structural transport system	Transport supply: Number of registered cars per 1000 inhabitants (n) Rail network: (Km/mln inh.) Rail network (n. stations/ mln inh.)

(Vale 2015)	cluster analysis node-place model, pedestrian shed ratio	Node-index: accessibility of the node	Number of directions served by train and/or ferry	y1 = number of train and/or ferry services offered at station
			Daily frequency of train and/or ferry services	y2 = number of trains and/or ferries departing from station on working day
			Number of stations within 20 min of travel	y3 = number of stations reachable within 20 min by direct trains and/or ferries
			Number of directions served by other public transport (bus, tram and underground)	y4 = number of public transport services offered at station
			Daily frequency of services by other public transport	y5 = number of buses, trams and underground trains departing from station on working day
			Distance from the closest motorway access	y6 = distance to next highway or freeway exit
			Car parking capacity	y7 = number of car places at station (free or paid)
		Place-index: intensity and diversity	Number of residents	x1 = number of residents within 700m
			Number of workers in retail/hotel and catering	x2 = number of workers within 700m in retail/hotel and catering group
			Number of workers in education/health/culture	x3 = number of workers within 700m in education/health/culture
			Number of workers in administration and services	x4 = number of workers within 700m in administration and services
			Number of workers in industry and distribution	x5 = number of workers within 700m in industry and distribution
			Degree of functional mix	$x6 = 1 - \frac{(\zeta_{y2}) - (\zeta_{y1})}{2}$ with $\begin{cases} \zeta = \max(x1, x2, x3, x4, x5) \\ \theta = \min(x1, x2, x3, x4, x5) \\ \zeta = \frac{(x1+x2+x3+x4+x5)}{5} \\ if - (x1 + x2 + x3 + x4 + x5) \end{cases}$
(Higgins & Kanaroglou 2016)	Latent class model-based clustering model-based latent class	TOD input measures for station typology analysis	1. Density:	Reflects density and the intensity of land use development in a station area. Calculated as total Population+Employment / Hectare within each station's theoretical buffer area.
			2. Development mix:	A statistic ranging between 0 and 1 that reflects the balance between population and employment in a station area. Calculated as the ratio of Employment to Population+Employment.
			3. Street connectivity:	Measures overall street connectivity and the quality of pedestrian access to the transit station. Calculated as the ratio of a station's 10-minute walk buffer on the local road network to its 800-m circular buffer. In this case, all station buffers were permitted to overlap to give a measure of overall street connectivity in the neighbourhood.
			4. Interaction potential:	Regional station accessibility and interaction potential, or measure of gravity considering population, employment, and travel time.
			5. Land use mix:	The proportion of residential, commercial, institutional, mixed, and industrial land in each station area. Commercial and institutional lands are combined into a single category.
		Output performance and additional descriptive measures	1. Transit commute mode share:	1. Transit commute mode share: Commute to work mode share for transit among those 15 years and older from the 2011 National Household Survey.
			2. Walking commute mode share:	2. Walking commute mode share: Commute to work mode share for walking among those 15 years and older from the 2011 National Household Survey.
			3. Cycling commute mode share:	Commute to work mode share for cycling among those 15 years and older from the 2011 National Household Survey
			4. Household VKT:	Total vehicle kilometers travelled divided by the number of households in the zones that make up each station area from the 2011 Transportation Tomorrow Survey.
			5. Average median household income:	Station area average of median household income values for each Dissemination Area (DA) from the 2011 National Household Survey, weighted by each DA's proportion inside the station area.
			6. Bachelor's degree and above:	Proportion of station area population aged 15 years and older with a Bachelor's degree or above 7. Population 20–35 years old: Proportion of the population that is between the ages of 20 to 25 in each DA from the 2011 Canadian Census. 8. Population 50–65 years old: Proportion of the population that is between the ages of 50 and 65 in each DA from the 2011 Canadian Census.

Vale (2015) studied TOD classification to obtain the relationship between land use, transport, and pedestrian accessibility. The node-place model, pedestrian shed ratio with cluster analysis wes implemented in the study. GIS application was complemented in the study. Based on the analysis of three values, the study concluded a balanced place-node is not necessarily.

Higgins & Kanaroglou (2016) discussed the performance of TOD based on inputs and outcomes. They applied latent class model-based clustering with multi-criteria research method. The study also outlined the type of station, based on the concept, and a significant level of the statistical indicators of each variable.

3.2 The strategic plan and the public transport plan worldwide.

Some of the strategy plan and public transport plan that implement TOD in transit areas in the world is a lesson that is applicable taken in real life, in the form of policies and actual implementation of the strategy as well as the contributing factors, in the form of the circulation which also passing the urban area (See Table 2).

Dorsey & Mulder (2013) describe a strategic plan and public transport in Ogden, Utah, USA. The strategic plan aim is to balance three things that are important in the development of the city, namely private aspects, society and Government.

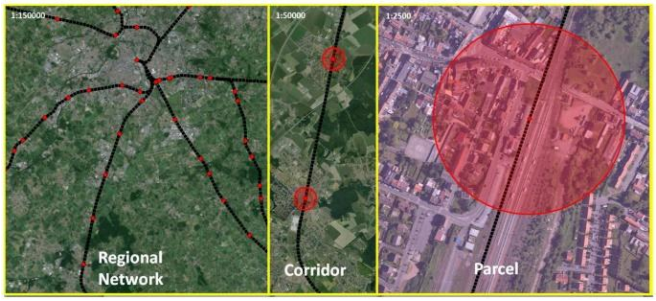

Fig1. Proposed Ogden streetcar routes. Source: (Dorsey & Mulder 2013).

All three components should work in harmony to achieve the goal of moving the city in the future. . The public transportation applied in the routes which being developed is able to commute the people and conjugates with other means of transportation. This is important to evoke the impression of a comfortable environment of the city as well as the awareness of the social interaction.

North-Pas-de-Calais region in French practices development using TOD for many years (Feudo 2014). Application of TOD in this region is expected to be made as the model for other cities development in France that offer mixed land use, locations near the point of transit, reduce land consumption, punctuality of transportation, and good quality of life in urban areas.

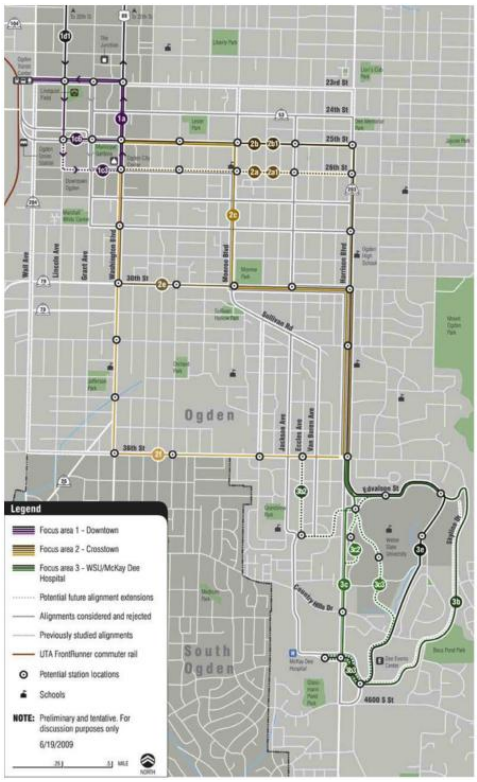

Fig. 2. Scales of TOD. Source (Feudo, 2014).

Policy integration between land use and transport on the view of regional planning implementation emphasize in supporting the activities near transit corridors to encourage the use of urban transport.

In Brisbane, Queensland, Australia, the strategy plan objective is to make Australia a strong, intelligent, green, and healthy nationby reducing congestion and by cutting one-third of the current carbon emissions (Kamruzzaman & Baker 2014).

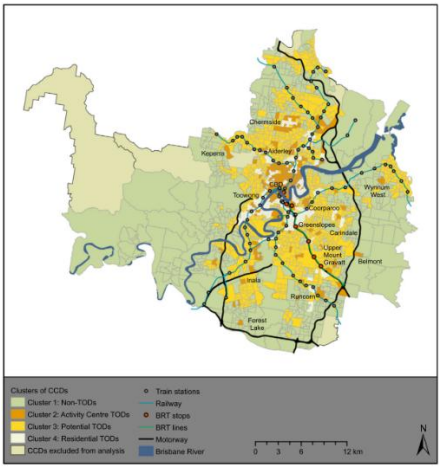

Fig. 3. Spatial distribution of CCD clusters in Brisbane. Source: (Kamruzzaman & Baker 2014).

Table 2.
The strategic plan and the public transport plan worldwide

No	Study	City	Country	Geographic area	Strategic plan	Public transport plan
1	(Dorsey & Mulder 2013)	Ogden, Utah,	USA	America	Balance within the triad of privatism, government, and community	Developing better bike routes, signage, and other amenities to make the city more pedestrian oriented
2	(Feudo 2014)	North-Pas-de-Calais	French	Europe	Integration between land use and transportation, it matches strategic perspectives of regional planning	Helping concentrate urban development and activities near transit corridors, inducing higher transit use.
3	(Kamruzzaman & Baker 2014)	Brisbane, Queensland	Australia	Australia	A strong, green, smart, and healthy state by reducing congestion and by cutting one-third of its current carbon emissions	Facilitating development in a more "compact way" through locating self-contained activities in well-defined nodes along existing and planned transport corridors
4	(Kwon 2015)	Sejong	South Korea	Asia	A new urban paradigm of construction reflecting the Korean experience	Mass transit stops and stations are located along pedestrian pathways, bicycle roads, community retail facilities, and public facilities.

The strategic plan and the public transport plan as above facilitate the development of better land use through transportation activities in the existing corridors. Therefore, future planning of the corridors can be developed for long term anticipation of a growing urban area.

A new paradigm of urban strategy plan of Sejong City, South Korea, focuss on the construction of the city that reflects the experience of Korea. The public transportation system was implemented to provide service which support the development by establishing stations located along the routes of pedestrian, bicycle paths, on-site retail community, and public facilities (Kwon, 2015).

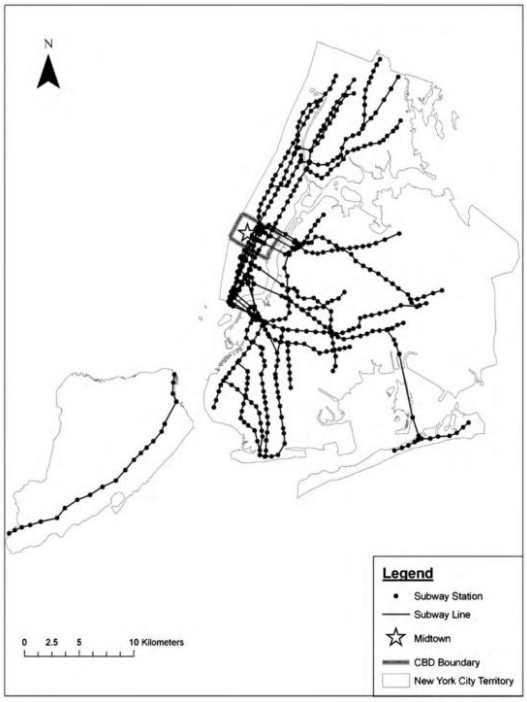

Fig. 4. The construction of the master plan that reflects the experience of Korea. Source: (Kwon 2015).

3.3 Cross-continent comparison of the transport and land use integration with TOD

TOD has been applied in many parts of the world, it was originated in USA, further spread to Europe, Australia and Asia. Each country has different characteristics in applying TOD. This section explained the successfull implementation of TOD with combines land use and transport (See Table 3).

USA is an excellent model of TOD application by the case of New York City (Loo et al. 2010) and San Jose (Mathur & Ferrell 2013).. Integration of transport and land use in TOD underscore the serious interest to the mixed land use because it is expected to maintain the traffic flow of passanger. Extensive network and high transit ridership of New York residents supported by the provision of heavy rail system. TOD is implemented within the transit are in which the interaction between modes of transportation is occured, such as bus and ferries.

TOD in the San Jose is served by a complete transit system using light rail line, commuter rail service and Rapid Transit District (BART). Integration of land use and transport is done by exposing both into a cooperative development on the station. The transit system was built by having the 67 of train that operates on the working days and 62 of train on the weekend. The interval time each train is 15 minutes. The stations located at the intersection of two major highways.

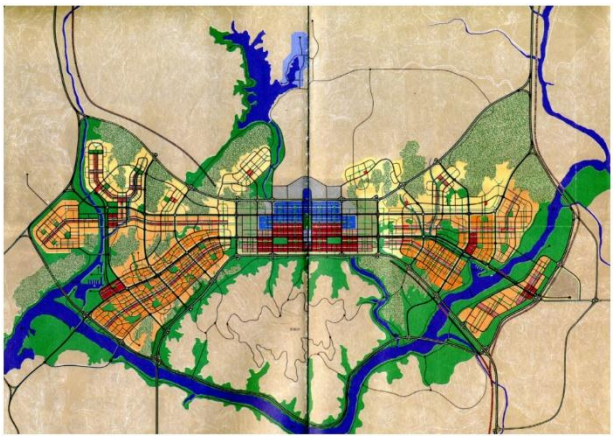

Fig. 5. The railway network of New York City. Source (Loo et al. 2010)

Lisbon, Portugal and the Region of Scania, Sweden are the examples of successful application of the TOD integration in the city and region scale. The application of TOD integration in Scania region, Sweden is carried out by the regional strategy to move the accessibility based on sustainable social facilities and environment (Qviström 2015). The point is the development of the city structure as the engine of growth towards sustainability and efficient, with no appeal of social and environmental.

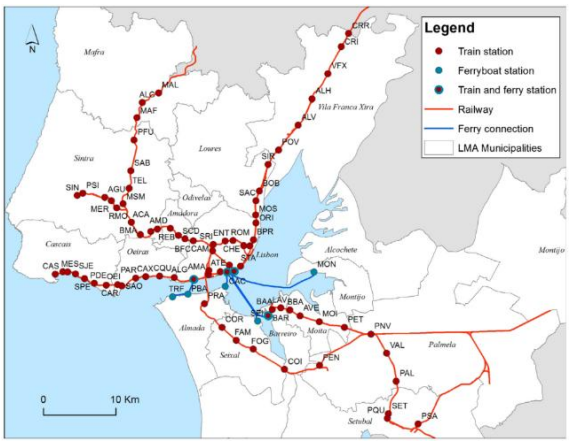

Fig. 6. The train station locations in Lisbon. Source (Vale 2015)

Table 3.
Cross-continent comparison of integration planning of transport and land use with TOD practice

No	Study	Case	Geographic area	TOD integration planning	
				Land use	Transport
1	(Loo et al. 2010)	New York City, US	America	✓ Mixed land use is conducive to railway patronage. ✓ Mixed land use help to generate bi-directional travel demand throughout the day	✓ Having well-established heavy rail systems, characterized by an extensive network structure and high transit ridership. ✓ The work trips were made by the subway system. Combined with the other public transportation modes, like buses and ferries
2	(Mathur & Ferrell 2013)	San Jose, US	America	✓ Emphasizing close land use-transportation integration. ✓ Joint development of station area public land (including sale or lease of air rights above the transit facilities such as the station or the rail line)	✓ TOD served by light rail line, commuter rail service and Rapid Transit District (BART), a heavy rail service. ✓ The station lies at the junction of two major freeways. ✓ 67 trains on the weekday and 62 on the weekend serve station at 15-min interval
3	(Qviström 2015)	Region Scania, Sweden	Europe	✓ Development of polynuclear structure, with special attention to cities acting as the growth engines for the region; which would be done with ✓ A call for "sustainable and efficient growth" of all settlements; and ✓ Which should be socially attractive	✓ Increased physical accessibility (primarily with public transportation), internally to "bind" the region together. and ✓ Externally to expand or strengthen the region;
4	(Vale 2015)	Lisbon, Portugal	Europe	✓ Developing significant suburban area. ✓ Urban development areas for both urban and transportation planning	✓ Reinforcing other places in the periphery of city as the main transportation interchanges. ✓ The development of a new suburban train line obliged to the construction of a new train station.
5	(Olaru et al. 2011)	Perth, Western Australia	Australia	✓ Emphasizing the creation of a mix of land use and residential density to attract trips, with	✓ Lying the station at the intersection of a primary distributor road and the main freeway.

				✓ access mainly by foot rather than car. ✓ Promoting mixed-use development.	✓ The station caters to car access (714 parking bays) and a feeder bus system along the distributor road that serves surrounding suburbs.
6	(Black et al. 2016)	Sydney, Australia	Australia	✓ Emphasizing for land-use developments along bus ways (transit lanes) in outer suburban.	✓ Applying suburban road-based "transit-way" (T-way) – or a bus rapid transit route.
7	(Li et al. 2013)	China's pearl river delta, China	Asia	✓ Encouraging development around stations by prioritiz-ing land quota for station areas. ✓ Applying a special zone policy to station proximity	✓ The construction of the line between two adjacent city to stimulate tourism industry and urban development ✓ Planning an inter-city rail transit network
8	(Sung & Oh 2011)	Seoul, Korea	Asia	✓ Applying compact land use pattern. ✓ Planning the quantity and quality of transit service, the density and diversity of land use and the features of the road network and urban design around the rail station.	✓ Managing rapid urban growth, were to be concentrated into a 1 km radius of rail stations in Seoul along the four railway lines under construction and four additional planned railway lines.

In line with Scania, Lisbon, Portugal also apply TOD integration through planning suburban areas and strengthen the outskirts of the city as the main place of transportation interchanges. Transport and land use are the key features of urban development in Lisbon (Vale 2015). Therefore, the application of urban planning in surrounding area of the station is important for the station sustainability.

Perth and Sydney experience of integration TOD is by applying a relation between form, use, transportation, density, urban development and the effect on the behaviour of human as the dominant factor. TOD in Perth started since the opening of the Mandurah railway station in 2007. Integration of TOD in transportation planning rejuvinates the quality of urban planning and social life of the community. The planning emphasize on the creation of a mixed use and density of settlements, other plan emphasize to attract pedestrian, i.e. putting the station on the intersection of the main distributor roads and freeways. The station also serve users of private car and service a bus feeder system along the distributor in suburban areas.

TOD and smart city was implemented in Sydney, Australia. TOD is in adjecent with the smart city movement where the concept of adaptation from beyond and performed by adjusting with the local conditions (Black et al. 2016)

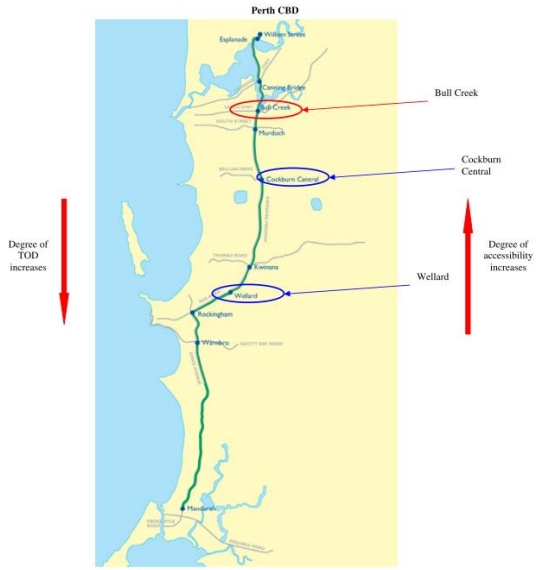

Fig. 7. Integration planning of TOD in Sydney. Source (Olaru et al. 2011).

. Integration planning of TOD in Sydney put on the land use development that located along the bus way or public transport lanes outside of the city. In addition, planning suburban road by implementing the transit way or a bus rapid route.

Cities in Asia have been an orientation to transit, such as Seoul, Korea and Shenzhen, China. In Seoul,

TOD is integrated through the application of compact land use patterns (Sung & Oh 2011).

The planning of the quality and quantity of the TOD services is done through the creation of the features of the urban design and road network in the surroundingarea of the train stop. The city government manage the rapid growth by emphasizing the concentration of areas within a radius of 1 km from the train station.

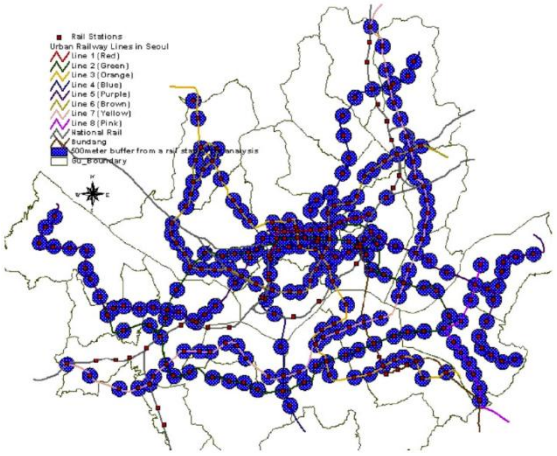

Fig. 8. Railway system in Seoul, South Korea. Sources (Sung & Oh 2011).

Integration of TOD in China stressed on the development of the area around the station with prioritizing land quota and applying special zone (Li et al. 2013). It connects two adjacent cities to evoke the tourism industry and urban development.

Fig. 9. Public transport plan in China. Source: (Li et al. 2013).

3.4 Finding

The concept of TOD ensure the existence of urban transport sustainability by integrating transportation networks to the growth of the city. This objective is manifested through the centralization of activities and developments around transit area. The concentration of activities near transit area will encourage the use of TOD. Therefore, it can gradually reduce car dependence.

Identification of the integration between transport and land usewith TOD in various cities of the world shows the transit area has an affinity towards many commuters. The transit area with a compact and diverse land use, which also completed with pedestrian path access, significantly able to attract larger numbers of commuters and it helps to decrease traffic congestion and environmental pollution.

TOD is an alternative to encourage the attainment of sustainable urban development where the principles of planning and designing adjusted for the purposes of the development level of the strategic urban environment.

4. Conclusion

Efforts to address problems of congestion and air pollution have been performed by the City Governments globally by implementing transport strategy. One of the above mentioned strategy is transport system plan-based mass transit in the city or regional scale. This planning is supported by structuring space and providing a connecting mode of transportation to facilitate passenger accessibility from the passanger's origin to their destination. However, the provision of mass public transport alone is not enough to cope with the urban problems such as congestion and pollution. A solution is required, in which the solution musta able to integrate land use and transport. One of the best solution is Transit Oriented Development (TOD).

Based on a review of the previos studies incorporated in this paper, practice and integration of TOD through land use and transportation showed that TOD can be the alternative solution in addressing the problems of developing urban area. The implementation of TOD is able to reduce congestion by facilitating the population preference of public transport compare to private modes of transportation and improved environmental quality. However, of course, it takes a strong commitment and consistency of the stakeholders to be involved in the implementation of TOD in a persistent manner.

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