Research Paper

Tackling Rapid Urbanization by Innovative Transit-Oriented-Development (TOD) Planning Approach in Jakarta

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Abstract

This research paper discusses the innovative urban planning approach undertaken at the early phase of Mass Rapid Transit (MRT) development project in Jakarta, to realize the healthy cities with transit-oriented-development (TOD). As rapid urbanization and lack of public transport service led to traffic congestion, external diseconomy is inevitable. Using the MRT East-West line development project as the study case, this paper examines the history of the MRT planning, its process and how the TOD concept is incorporated in the process of railway engineering. It is found that the quantitative analysis approach with utilization of the satellite big data worked effectively to identify the land use and existing population, and it was utilized for the passenger demand forecast. The result shows that the increase of residents and workers by TOD implementation will be significant. While there is no doubt on the importance of applying TOD concepts toward a decarbonized and walkable city, its success may highly depend on how the theory is converted into the practice when the large-scale infrastructure project proceeds. Smart use of big data can make sure to deliver the best planning approach and its outcome to realize equitable and sustainable cities which in turn will tackle the rapid urbanization and urban issues in Jakarta.

Keywords

Big data, innovative approach, MRT, public transportation, TOD, urban planning

1. Introduction

Indonesia has been growing rapidly and the country's economic position in Asia is becoming increasingly important. With a population of 31.40 million, Jabodetabek region, a greater Jakarta consisting of the Special Capital Region of Jakarta (DKI Jakarta), greater Bogor, greater Bekasi, and greater Tangerang, plays a significant role as the economic center as well as the capital of Indonesia. This megacity, forecasted to become the world's biggest city by 2030 (Euromonitor International, 2021), is also well known for external diseconomy generated by rapid urbanization, such as traffic congestion. As one of the largest urban areas in the world, Jabodetabek is experiencing a slow development of urban transportation infrastructures. Compared to other big cities in Asia like Tokyo, Singapore, and Kuala Lumpur, Jakarta's mass rapid transit (MRT) and light rail transit (LRT) line are lagging behind with only 16 km MRT and 5.8 km LRT network operated. On the other side, Jabodetabek is experiencing the unprecedented growth in car and motorcycle ownership as well as drastic change in modal share to only less than 10% (JUTPI 2, 2019). As a

result, traffic congestion occurs and it leads to a huge economic loss and deterioration of the urban environment.

In order to solve such issues, urban planning as well as transportation infrastructure development inevitably plays a significant role, and the Indonesian Government plans and executes a series of policies and projects such as development of quality public transportation infrastructure. Among those, transit-oriented-development (TOD) is considered an effective measure to integrate land use and transport planning to enhance a walkable and non-motorized environment. The Jakarta MRT East-West line project, which has been stated as one of the National Strategic Projects (Committee for Acceleration of Priority Infrastructure, 2022), is planned as MRT Phase 3 project that spans approximately 87 km from Balaraja in Kabupaten Tangerang, Banten Province, passing DKI Jakarta's administrative area towards the end line in Cikarang, West Java. As the case study, this paper discusses the TOD planning especially in the rapidly urbanizing cities, with the focus on how the TOD concept can be integrated into the urban transportation infrastructure planning.

2. Methodology

Characteristics of urban fabric are oftentimes largely affected by the planning process of the city especially when large-scale infrastructure developments proceed. In order to carefully examine its planning process and extract the essential elements from the practice to discuss the research question, the case study approach is applied. Taking the Jakarta MRT East-West Line Project as the case, the study is conducted in accordance with (1) literature review, (2) data collection and analysis of socio-economic conditions in Jakarta, planned mass transit network in Jakarta, and TOD regulations and guidelines in Jakarta, (3) case study, and (4) analysis and conclusion respectively. The methodology of the case study is further broken down into (a) the planning process of the studied case, and (b) the scope, approach and methodology taken at the basic design phase. The overall flow is shown below.

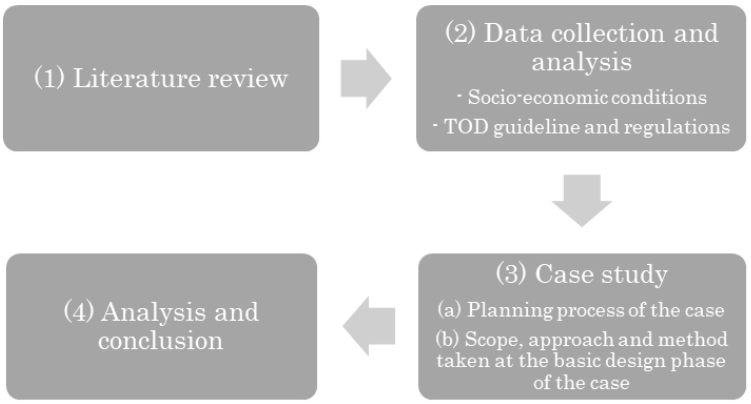

Figure 1. Research Methodology. Source: Author

3. Literature Review

TOD is an urban development concept proposed by American architect Peter Calthorpe in the late 1980s. In general, TOD is defined as a mixed development that encourages people to live close to public transport (transit) services and to decrease their dependence on driving (Still, 2002). This emerged as an effort to overcome urban problems in the United States such as decreased trade in urban areas, job losses, population shifts and community declines that occurred due to the development and motorization of suburbs since 1950.

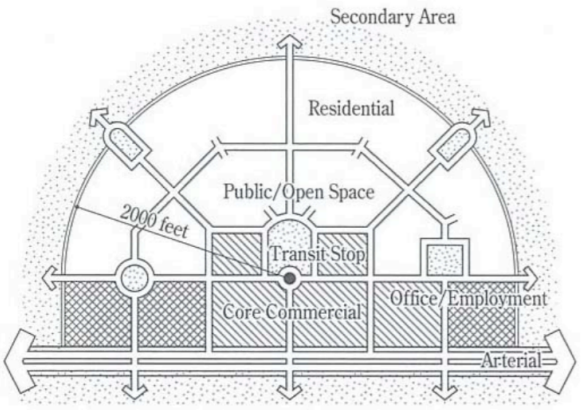

Figure 2. TOD Concept by Peter Calthorpe. Source: Calthorpe, 1993.

The basic concept of TOD emphasizes a mixed environment with an area of between 8 and 65 hectares located within an average walking distance of 1.6 - 6.4 kilometers from a transit stop. The TOD area is developed around mass public transport stops and commercial areas as primary areas. Secondary areas are lower density housing, schools, parks, and commercial uses. The TOD must be on a trunk line network (either light rail or bus line) or a feeder bus line network segment within 10 minutes of public transit travel time from the main network. Regarding the compact development concept, Ewing and Cervero (2017) argue that the benefits of compact development range from increased walking and transit use, reduced pedestrian and motor vehicle fatalities, to increased sense of community, and increased social capital. Improvement of accessibility and mobility supported by the TOD concept is able to reduce high dependence on the use of private vehicles and direct the public to walk or use a bicycle for their activities. In addition, environmental development combined with the rail mass transit system, will reduce the number of drivers on the road and encourage a more compact growth pattern by attracting residents close to train stations (Bowes and Ihlanfeldt, 2001).

Some of the TOD concept practices have also been applied in several cities in the United States, England, Japan, Hong Kong, and South Korea. Furthermore, urban area management in developed countries which have implemented TOD seems capable of increasing the property values and reducing household expenditure for transportation costs (Syabri, 2011). There are also several studies to quantitatively measure the level of TOD. Singh et al. (2014) measured the existing level of TOD using criteria such as urban densities, land use diversity and economic development levels. However, most of those are limited to the analysis of the existing conditions and not intended to be utilized for the public transportation infrastructure planning. Sectionalism also constitutes the obstacle to integrate the urban planning and transportation project. Nakamura (1998) points out that organizational structure as well as bylaws in Japan are one of the most critical issues which prevent a policy integration of transportation goal and spatial planning goal from its success.

4. Socioeconomic Condition in Jakarta

DKI Jakarta Province covers an area of 664.01 km^2 which consists of five administrative cities and one regency. It is inhabited by 10.56 million people in 2020 with a density of 15,907 persons per km^2. The annual population growth has decreased over decades, 0.92 during 2010-2020 and the sex ratio of 102.06. Most of Jakarta's population are in the productive age, especially the 35-39 age group. According to the national census, the dependency ratio of Jakarta is 44.7 which means that of 100 productive age population of DKI Jakarta will bear nearly 45 population of unproductive age.

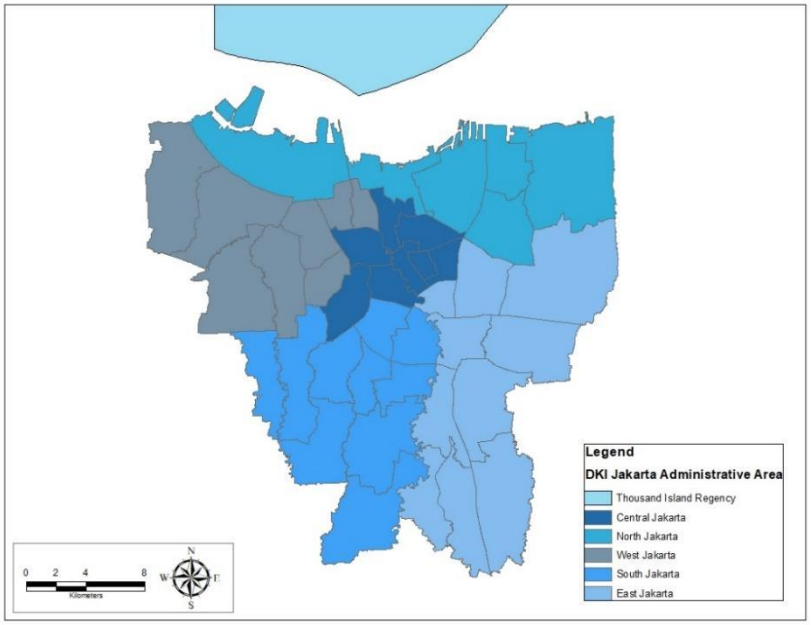

Figure 3. DKI Jakarta Administrative Area. Source: GIS, 2022.

In terms of economic activities, DKI Jakarta's Gross Regional Domestic Product (GRDP) at constant price year 2020 is recorded at IDR 1,792 trillion (USD 120.70 billion) and GRDP per capita of IDR 169.7 million (USD 11,428). The economic growth has increased steadily until 2019 with 6% before being hit by the pandemic. During the pandemic, the economic growth decreased to -2.5% in 2020 and started to recover in 2021 with 3.6%. Economic structure of DKI Jakarta in 2020 was dominated by the service industry which contributes to more than 70% of Jakarta's GRDP. The biggest portion came from wholesale and retail trade; repair of motor vehicles and motorcycles sector that reached 16,62% from the total GRDP.

5. Planned mass transit network in Jakarta

Jakarta is connected by various mass transit; commuter line, MRT, LRT, and airport link. Among those, the commuter line has the longest line with 418 km in total. A breakthrough of public transport emerged when MRT Jakarta started to operate the North South line phase 1 along 16 km from Lebak Bulus to Bundaran HI. The extension of the line is now undertaken for 11.8 km length to the north side from Bundaran HI to Ancol Barat. Currently, DKI Jakarta is working on the formulation of transportation master plan and railway master plan which focused to extend the current network and connects the east and north side with new lines in form of LRT and other form of urban railway (*Perkeretaapian Perkotaan Jakarta*/PPJ). By 2039, it is estimated that the railway network in Jakarta will be expanded to more than 250 km.

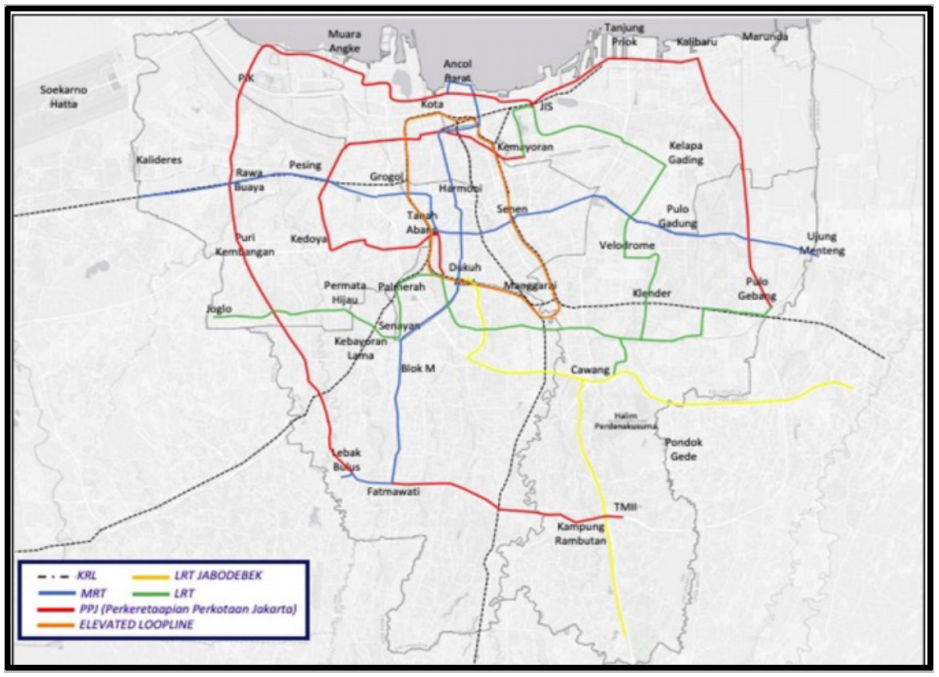

Figure 4. Planned Railway Network in 2039. Source: Railway Master Plan of DKI Jakarta (draft)

This study focuses on the basic design of MRT East-West line, a national strategic project that spanned from Balaraja in Banten Province to Cikarang in West Java Province. MRT East-West line is planned with a total length of approximately 87 km; one-third each in Banten Province, Jakarta, and in West Java Province respectively. This line consists of 48 stations in total, 40 elevated stations and 8 underground stations and is planned to be constructed in 2 phases. In DKI Jakarta Province, the MRT East-West line is planned to run from Kembangan to Ujung Menteng, with a total length of 33 km with a total of 25 stations, consisting of 8 underground stations and 17 elevated stations.

6. TOD Regulations and Guidelines in Jakarta

In Indonesia, TOD regulations have been legalized to enforce the implementation of TOD and it acts as an urban planning tool to activate the operational mechanism. There are three regulations confirmed as of August 2022:

1. Ministry of Agrarian and Spatial Planning/National Land Agency (ATR/BPN) "Guideline of Transit Oriented Area Development." as stated in the Ministerial Regulation of Agrarian and Spatial Planning/Head of National Land Agency No. 16/2017
2. Technical guidelines for the transportation aspect in implementing TOD in the Greater Jakarta (Jabodetabek) area by BPTJ (Greater Jakarta Transportation Authority) as stated in the Decree of Directorate General of BPTJ No: PR .377/AJ.208/BPTJ-2017.
3. Governor Regulation No. 67/2019 on the Development of Transit-Oriented Development Area.

TOD guideline by ATR/BPN has defined the principles of TOD, area selection, area development, and institutional framework. It is parallel to the general planning of each administration from the national level to the city level that states typology, characteristics, and criteria. Determination of TOD area should reflect or make some modifications to the detailed plan or zoning, and the Urban Design Guidelines (UDGL).

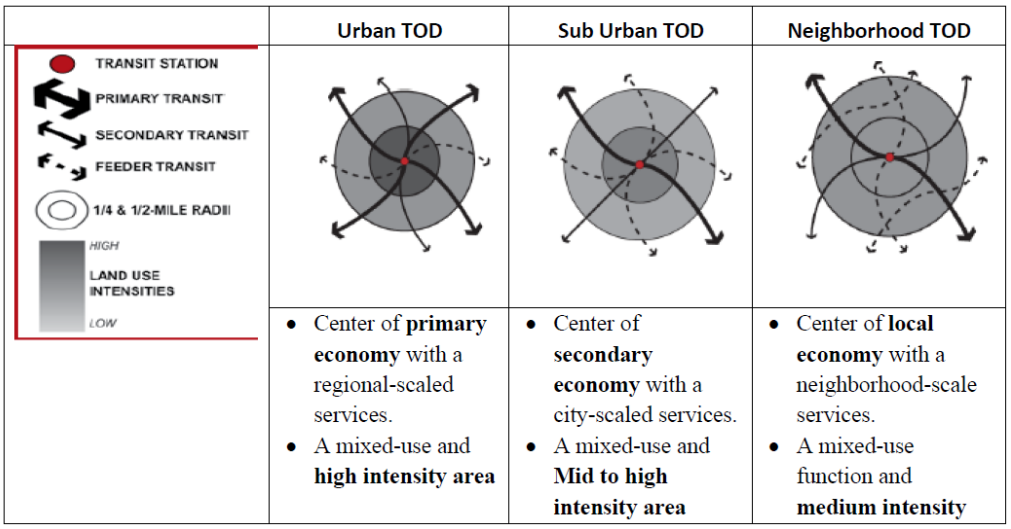

Figure 5. Typologies of TOD Area. Source: Minister Regulation of ATR/BPN No. 16 Year 2017

BPTJ's regulation emphasizes the technical aspect in terms of integration between spatial planning and transportation which correspond to five principles of transportation in TOD, namely connectivity, public transport, walk, cycle, and modal shift. It details several technical terms in the transportation aspect, including the minimum standard of facilities to be fulfilled.

Compared to the others, DKI Jakarta's regulation is more operational and technical. There are 6 scopes presented; criteria and principles, institutional aspect, zone development mechanism, development of transit-oriented area, technical provisions for spatial use, and incentives, disincentives, and management of land value capture. The regulation tried to incorporate inclusion planning with a provision of affordable flats and business space in the TOD area that allow people with limited purchasing power to access residential in TOD area. One of the merits of this regulation is about detail on the requirements: study elements, TOD elements, and institutional aspects. Besides, some technical requirements for TOD elements were also described such as: pedestrian facility, bicycle facility, connection facility, etc.

As the center of national activity, DKI Jakarta sets a benchmark for TOD implementation. In the recent revision of spatial plan, TOD and digital city have been approved as the city's vision to achieve 55% mode share and concentration of activities and residents around transit point as many as 70% people live near transit. To do so, both supply and demand driven strategies are planned, by developing pedestrian and bicycle paths, expansion and integration of public transport, traffic restrictions, park and ride, and transit-based compact area development.

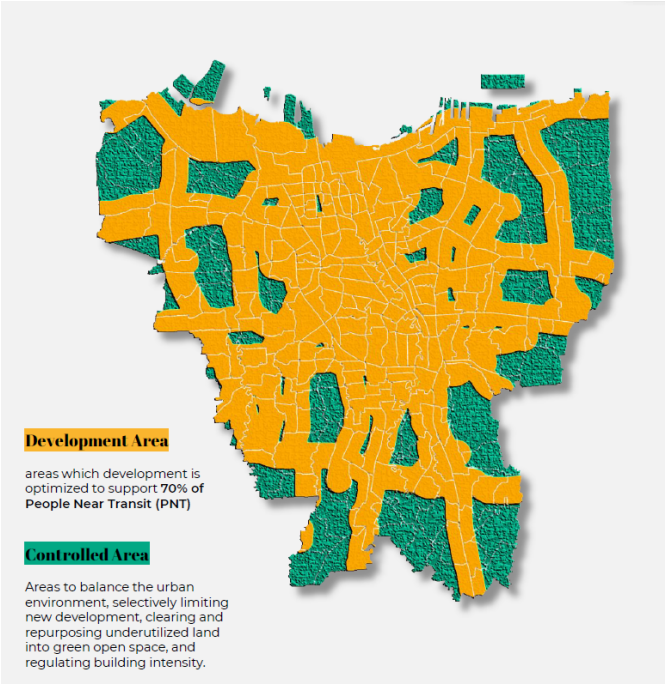

Figure 6. People Near Transit Concept. Source: Revising Spatial Plan (RTRW) of Jakarta 2042

Detailed spatial plan (RDTR) of DKI Jakarta defines the planning criteria for TOD, including the technical provisions for each type of TOD. In RDTR, there are 6 areas along the existing MRT North South Corridor which urban design guidelines (UDGL) have stipulated. UDGL regulates the implementation mechanism and strategy: property right and development right, land development strategy, land value capture (LVC), incentive, and others. Given those rules, master developers can initiate the TOD area by formulating UDGL. However, they should be a State-Owned Enterprise (BUMN), Regional Owned Enterprise (BUMD), Government, Private Sector cooperation/partnership with Government.

7. Case Study – Satellite Data-Based Quantitative Analysis to Determine TOD Stations

7.1. Planning process of the case

There is a long history of the planning of the mass transit network in Jakarta or the greater Jakarta area. According to the study conducted by the Japan International Cooperation Agency (JICA), annual population growth rate of greater Jakarta outside Jakarta (BOTABEK) was 3.7% between 1990 and 2000, while that of Jakarta was 0.2%, and it indicates rapid suburbanization of greater Jakarta (Japan International Cooperation Agency, 2001). The concept of the MRT line was already in place in the late 1980s (Japan International Cooperation Agency, 2001). The Indonesian Government appointed the private consulting firm to conduct the basic design of the MRT project in 1996.

On the contrary, the Asia crisis in 1997 seriously impacted the national account of Indonesian Government and caused significant delay in infrastructure projects. When it comes to the development budget of the public transport sector, shortage of national budget led to dependency on the international loans and its proportion reached 69% out of the budget for public transport in 2000 (Japan International Cooperation Agency, 2001).

JICA conducted the study to review the existing conditions and proposed the short-term master plan to identify the transportation projects with urgent needs, which also included the MRT. The proposed conceptual transportation system development master plan by JICA is shown as follows (Japan International Cooperation Agency, 2001).

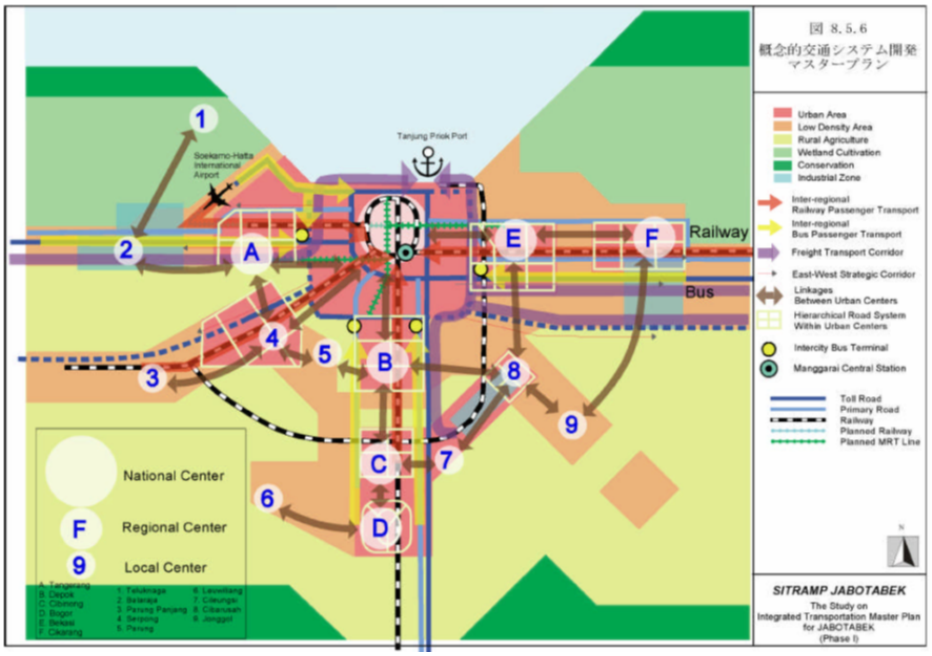

Figure 7: Proposed Conceptual Transportation System Development Master Plan by JICA in 2001. Source: JICA

In this study JICA also reviewed and proposed the alternative MRT alignment as shown below.

Figure 8: Proposed Jakarta MRT Alignment by JICA in 2001. Source: JICA

Seven years after JICA conducted the feasibility study of MRT East-West line in 2013, Indonesian Government procured the consultants to finalize the railway track alignment and prepare the technical documents of basic engineering design in 2020. Since this is the railway project passing through several Provinces, the Directorate General of Railways under Ministry of Transportation of the Republic of Indonesia took charge of and led the project.

7.2. TOD planning approach and methodology taken at the basic design phase

The MRT East-West line project passes three Provinces and its railroad length exceeds 80 km, with more than 40 stations planned within it. Having been designed to meet the commuter's demand, it is planned to connect suburban areas with the city center and pass both built-up and greenfield areas. In parallel with basic studies such as geology-geotechnical survey, passenger demand forecast, track construction type examination such as elevated or underground and basic design of station buildings, TOD study was also conducted. Considering the phase of the project and authority of the project implementation body, the study followed the approach of (1) recommending the TOD station areas and their typologies, and (2) measuring the impact of TOD and incorporating it into passenger demand forecast.

As described in the previous section, Indonesia has the guideline on the typology of the TOD depending on its characteristics. Some Regencies and Cities designate the certain station areas as the TOD in their spatial plan in accordance with such guidelines. In the MRT East-West line project, each station area along the planned MRT East-West line was examined referring to TOD the guideline as well as the regional spatial plans, and focus group discussion was held for a few times to listen to the plans and opinions of each municipality and stakeholder authority. As a result, 23 out of 48 stations were recommended as the TOD station areas. Among those, 9 station areas were recommended as the City Center typology with more retail and commercial land use set than those of other areas.

Based on the above result, impact of TOD was quantitatively assessed to incorporate it to the passenger demand forecast, under the objective that future benefit of TOD can be counted in the ridership forecast. The study process is broken down into two: without-TOD scenario setting and with-TOD scenario setting. For the without-TOD case, the population with the existing condition was calculated and adjusted to the forecast year. In order to efficiently collect such information within time constraints, the AW3D Building dataset was utilized in combination with the site inventory survey to study the population of "without" TOD case. AW3D Building dataset is the 3D vector data with high-resolution and it enables the immediate capture of building volume information of the study area. The specification is shown as below.

Item	Description
Product Type	3D Vector (Digital Height Data, Polygon Type)
Satellite	Maxar Technologies - WorldView
Projection	WGS_1984_UTM_Zone_48S
Datum	D_WGS_1984
Horizontal Accuracy	2 m RMSE
Vertical Accuracy	1-2 m RMSE
Delivery Formats	Shape format (.shp)
Attributes	Above Ground Level (AGL) (unit: meter)

Figure 9: Specification of AW3D Building Dataset. Source: NTT Data

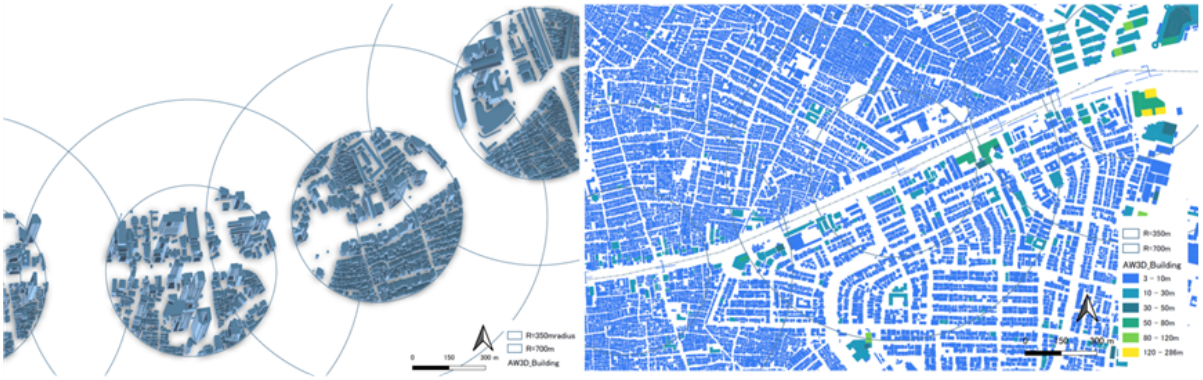

Figure 10: Image of AW3D Building dataset. Source: Author

While the AW3D Building dataset is useful in obtaining building volume of the study area, it is still not perfect and requires additional surveys to come up with the estimated population of the study area. In order to identify whether each building is of an office use, retail use, school use or residential use, a supplemental site inventory survey was conducted in the 15 representative areas to collect information on the floor use of each building.

For the with-TOD case, it was more systematically calculated using the floor area ratio, and land use mix set out in the TOD guideline. Indicators for population units were selected from both international and domestic guidelines and applied to calculate both resident and worker population from the gross floor area. And finally, the difference of population between “without” and “with” TOD case was extracted for each TOD station area and incorporated into the passenger demand forecast.

The result showed that the increase of residents and workers will be significant with TOD implementation, over 126,000 and 122,000 persons respectively for the phase 1 area with 21 stations. These figures were reflected in the passenger demand forecast for the MRT East-West line and furtherly examined to impose a decision on the project phasing and future area development.

8. Analysis and Conclusion

Large-scale transportation infrastructure projects involve a lot of decision making and it usually takes a long time to see its completion. In the case of the MRT East-West Line project that has still been in the planning and development process after 20 years, the major cause for delay was financing. At the MRT East-West Line project, TOD concept was adopted in the early stage of railway engineering design, and this is expected to effectively work towards successful integration of public transportation planning into TOD for several reasons: early adoption of railway corridor-based spatial planning, early engagement of government stakeholders, design consideration of pedestrian access and intermodal facility at the station building, and so on. In this sense, it can be emphasized that intervention of the planning in the early engineering design stage of the infrastructure development is effective, and that smart use of big data can make sure to deliver the best planning approach and its outcome to realize equitable and sustainable cities which in turn will tackle the rapid urbanization and urban issues in Jakarta.

On the contrary, early adoption of the TOD concept in the public transportation project could potentially cause another challenges in the planning process: timeline gap between urban fabric transformation and railway development, risk of changing socio-economic conditions and its impact to the assumption base of quantitative analysis as the project is delayed, and so on.

While there is no doubt on the importance of applying TOD concepts toward decarbonized and walkable cities, it requires further efforts for planners to convert the theory into the practice by tackling practical issues. This case study reveals the important facts again that there is no one-size-fits-all planning approach or process, yet it is always subject to the practitioner on how the planning theory is adapted and how it is tackled toward realization of equitable and sustainable cities.

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