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M B Susetyarto

1Department of Architecture, Trisakti University, Jakarta, Indonesia

Corresponding e-mail: bambang.s@trisakti.ac.id

Abstract. Nowadays, urban transportation spaces with high levels of traffic density are not safe and comfortable to use. The impact of the disruption on human mobility, goods and services, and the impact of environmental degradation, as well as the declining quality of human life have been experienced by residents of metropolitan cities, including people of the Jabodetabek area. Therefore, the concept of Transit Oriented Development (TOD) is relevant to be applied to the development of these urban areas. The problem then arises is that the application of the TOD concept will have an impact on changes in land use and zoning, and on changes in social, economic and cultural behavior of the community. The urban spatial plan in Jabodetabek may not ready to accommodate the concept of developing the TOD area. This research needs to be done to answer the following questions: 1) how changes in land use and zoning occur in TOD-based development areas; 2) what is the pattern of people's behavior, the pattern of movement of goods and services from an origin to a destination, in a large number of mobility in limited space and time? The research method is designed as follows: 1) observing the application of current land use and zoning regulations, 2) observing the pattern of movement of people, goods and services from the trip generation point to the destination point, or vice versa, including observing the condition of urban facilities and infrastructure that supports the pattern movement, 3) analyzing land use and zoning regulations, as well as deviations in implementation of land use and zoning, 4) analyzing patterns of movement of people, goods and services, utilization patterns of urban facilities and infrastructure, 5) designing an architectural model for the Bogor Station, which is TOD-based. Based on the modeling it is then simulated and evaluated by experts, then analyzed and synthesized, and produces the next variant design modeling. And so on, these iterative process are carried out over and over again until they reach a model which is considered to meet the design criteria of Bogor TOD Station area, in harmony with the vision of Bogor sustainable development, and is feasible to be realized. The final design model is the findings of this research. The copyright will be taken care of, and further it will be donated to the Bogor City Government as a design model for the development of Bogor Station TOD area.

Keywords: development, model, Bogor, station, TOD.

1. Introduction
The development of urban areas in Jabodetabek in last decade is more oriented to the pattern of movement of people, goods and services. Development of satellite cities in the suburbs will only succeed, if there is good accessibility support, such as highways, railways, as well as the availability of adequate infrastructure. Based on those issues, the Government regulated the implementation of TOD concept by the ATR ministerial regulation number 16/2017 and the DKI Jakarta regulation number
The implementation of the TOD concept in the Jabodetabek urban spatial planning done by maximizing the use of mass transportation and connecting pedestrian networks. By doing so, architects and urban planners were expected to pay attention into design of movement space, which was safe and comfortable for people to walk, and was smooth for the movement of goods and services. Actually, realizing the TOD area was an effort to meet the basic demands of environmental sustainability, social justice, community welfare, and security for its users. In order to find the best solution to realize the movement of people, goods and services, which are free from congestions, air pollution, noise pollution, and energy waste, a comprehensive analysis is needed. The analysis referred to the existing land use and infrastructure, environmental condition, affected areas of development, and socio-cultural interactions towards a new lifestyle, i.e. communal trip by public transportation. The sharpness of the analysis resulted in a synthesis of programmatic concepts and schematic design, i.e. architectural model of the Bogor Station area, which is a case study in this research.

Some phenomena considered in the planning and designing the TOD area were the changes in land use and zoning, building density, environmental degradation, a number of heritage buildings around the train station, the density of trip during peak hour of activity, as well as changing between modes i.e. from commuter line to train line, or to other public transportation line, or vice versa. The Bogor Station area has a huge density of passengers and quite dense commercial activities around it. Human activities in the Bogor Station area seemed to never sleep until late at night. However, land use arrangement in the Bogor Station area was not supporting safetyness and comfortableness for pedestrians, public transportation passengers, and informal sectors in order to use urban corridor nicely. Therefore, it is necessary to develop a TOD area to facilitate transit passengers from Bogor Station to the next trip point, or other points of attraction. For example to the bus shelter, the ojek base, the traditional market, etc. The big theme of TOD area development was the integrated arrangement and revitalization on the Bogor Station area and its surroundings [1]. By an architectural model made based on the synthesis, a simulation and evaluation was carried out by urban development experts, and the results of the evaluation became the basis for the next modeling. These experimental research methods were applied to obtain design models that were considered valid for the TOD-based area development process in the Bogor Station area. The evaluation criteria used were ease of pedestrian mobility, justice to get equal access to urban facilities / infrastructure, affordability of urban space for all levels of society, a better quality of life with reducing reliance automobile, and it can reduce emissions / pollution.

2. Literature Review, Principles and Regulations

2.1 Literature Review

Calthrope defined that a transit-oriented development is a mixed-use community within an average 2,000-foot walking distance of a transit stop and core commercial area [2]. There are several terms that are close to the TOD concept and are often associated with each other, such as the transit village, pedestrian pocket, and new urbanism. The four concepts have similarities and differences according to the context and background of their emergence. The transit village means a compact, mixed use community, centered on the transit station that by design invites residents, workers, and shoppers to drive their cars less and ride mass transit more [2]. TOD is strategy to make cities more efficient in people’s transportation systems, including the movement of goods and services, with the development of mixed function areas in urban activity centers around train stations, with safe and comfortable areas for pedestrians [3]. The TOD-based urban structuring model is a form of habitability and sustainability of the urbanization process related to housing, workplaces, and other urban activities that can be reached on a pleasant, safe, easy and convenient walk to and from the train station, instead of traveling carried out by private car to the destination transportation system [4]. Therefore, design, configuration, and mixed-use area oriented to walkable zones, which use public transportation modes, without ignoring private vehicle modes.
2.2 Principles

Integration of transit on a regional basis and walkability in neighborhood are the emphasize of TOD principles. Peter Calthorpe (1993) has summarized the urban principles associated with TOD [5]:

- Organized growth on regional level to be compact and transit-supportive;
- Place commercial, housing, jobs, parks, and civic uses within walking distance of transit stops;
- Create pedestrian-friendly street networks which directly connect local destinations;
- Provide a mix of housing types, densities, and costs;
- Make public spaces the focus of building orientation and neighborhood activity;
- Encourage infill and redevelopment along transit corridors within existing neighborhoods.

As a strategic steps to achieve the objectives of the TOD concepts, namely to provide an alternative for the development of cities, urban sub-regions, area and ecological environment, eight urban design principles are formulated in TOD as quoted from TOD standards, namely:

1) walking which is the most natural, healthy, emission-free and affordable mode of transportation, and is an important component of a trip with public transportation;
2) cycling which is very efficient and consumes very little urban space and resources;
3) connecting which is short and direct pedestrian path require a dense road network between permeable small blocks;
4) transit which is public transportation connects and integrates urban areas too far for pedestrians;
5) integrating land use and zoning in one area will make local roads continue to live and provide security, encourage walking and cycling activities, and form a humane environment;
6) densification which is able to sustain urban growth in a tight and dense spatial pattern, cities must grow vertically rather than horizontally;
7) compact which is the basic principle of dense urban development is compact city spatial planning. In cities or suburban areas that are crowded, various activities can be held close to each other; 8) switch/changing which is equipped with intermediate modes of transportation or rental that are more efficient in the use of urban space.

The following are other principles and indicators of the TOD concept, i.e.

a) According to TCRPC (2002) and TCRPC (2012) the level of occupancy or property density is an indicator that can explain the principle of density [6]. While ITDP (2015) tends to pay attention to the level of land use density based on the coefficient of building base (KDB) and the coefficient of building floor (KLB) [7]. Land use density will bring various activities closer to maximizing the use of public transportation modes.

b) The land-use mix aims to support mobility efficiency and improve the livability of the area by integrating occupancy with workplaces, shopping, and schools. The principle of mix aims to bring the inter-use of land related so that it will encourage walking and cycling activities of the surrounding community (ITDP, 2015) and TCRPC (2002) divides mixed-uses indicators into two things, namely the amount of mixed land use, and retail presence with various service scales [6,7].

c) Pedestrian lanes are needed to support movements that are oriented towards the uses of mass public transportation by providing infrastructure that is able to provide comfort and safety for pedestrians, including cyclists.

d) Interconnection of road and block networks is needed to form a walkable environment. A dense road network with a composition of small roads and a high number of intersections will slow down the vehicle so that it can provide benefits for pedestrians.

e) Parking in the TOD concept is directed to parking restriction systems by providing fewer parking spaces at the center of the transit area than in the secondary area (TCRPC, 2012) [6]. The method of district-wide parking by providing collective parking, i.e. parking building, parking cluster, or transit point parking facilities.

f) Open space has a role as a place for social interaction while creating harmony in the landscape amid the high intensity of land use. The location of open spaces in the TOD concept area can be near the transit point, road boundary, residential area, or a place around the retail area.
2.3 Regulations

2.3.1 The Urban Spatial Planning of Bogor City [8]. Regarding to the Urban Spatial Planning of Bogor City, the Bogor Station Area is defined as a Cultural Heritage and Science Area. The Bogor station and surrounding area are included in the urban spatial planning and revitalization plan, infrastructure and pedestrian facilities plans, development plans for mass public transportation routes in the city, planning for street vendors and the development of the Kebon Kembang Market area, and as one of the main program indications in Integrated Railway Development Network.

2.3.2 Guidelines for Development of Transit Oriented Development (ATR/BPN Regulation, No.16/2017) [9]. This Ministerial Regulation is intended as a reference for the Government, Provincial Governments, and District/City Governments, in the determination and decision of TOD locations and the development of the TOD area and aims to realize a transit environment as a TOD region that has added value and creates a healthy business climate and conducive to improving regional space structure and increasing regional development capacity. The Ministerial Regulations provides guidance on matters as below:

a) Determine and decide the location of the TOD region in the preparation of the Urban Spatial Planning of Bogor City;

b) Formulate provisions on the use of space and technical provisions in the implementation;

c) The technique of zoning arrangements for the TOD area regulated in the Detail Spatial Planning (RDTR) and Zoning Regulation (PZ);

d) Design building and environment in the Building and Environment Spatial Planning (RTBL).

Meanwhile, the scope of this Ministerial Regulation includes 1) TOD principle, 2) determination and decision of the location of the TOD region, 3) development of the TOD region, and 4) institutional TOD area.

2.3.3 Building Intensity. Building intensity is a provision regarding the size of buildings allowed on a land which includes the maximum KDB, maximum KLB, maximum Building Height, maximum KDH, maximum KTB, and maximum number of basement floors that must be fulfilled by the applicant for establishment of a building. In addition to fulfilling these provisions, specifically for applications for the establishment of high-rise buildings, the applicant must attach a study of building height analysis by considering: 1) ambient lighting; 2) wind factor; 3) accessibility of fire hazard prevention; 4) space carrying capacity; 5) environmental carrying capacity; 6) ability of carrying capacity of soil structure; 7) building structure safety factors; 8) technology implementation methodology; 9) consider the functions of criteria special buildings in the vicinity such as: Presidential palace, Military complex, High Voltage Air Channels, Landmarks, and 10) consider the limits of the Aviation Operation Safety Area (KKOP) for parts of West Bogor District and Tanah Sareal District.

3. Methods

3.1 Behavior Mapping and Behavior Analysis
In order to record the data of people’s behavior pattern, I used the behavior mapping. By this method, I understood the patterns of train passengers; both commuter line passengers and the Bogor-Sukabumi train passengers, and other city transport passengers, as well as the movement of people who were not public transport passengers. In addition, behavior mapping was also used to understand the pattern of movement of goods and services in the Bogor Station area. Further the data was used to analysis by determining the pattern of travel or movement of humans with the use and interaction between open space and the built environment. This behavior analysis was served to provide an understanding of how the built environment can affect activities and habits carried out by humans. This kind of observations can help in expressing the concept of development design and changes to space and place. Systematic observation and recording of patterns of human behavior through mapping and
categorization of activities can also be called activity mapping. Mapping these activities included recording and mapping the movement patterns of people who used space or place, including how the use of it. Behavior observation also included physical trace observation. The trail that was traversed by humans included a path that might be proof that humans adjust to the place they passed. This observation can be expressed in the form of a map, describing, and counting or a combination with other methods, such as interviews and user observations that were used to make hypotheses about the reason the tracks were passed.

3.2 Experimental Design Process
After completing the behavior analysis, I used the result of the behavior analysis to be input on experimental design process in order to make an architectural model of Bogor Station area, which is TOD-based. I paid attention especially into realize safe and comfortable corridors. Analysis of circulation patterns as findings of behavior mapping were met with the result of the analysis of existing changes in land use and zoning. Further, the result of it was combined with the analysis of configuration of building masses, public open spaces, and green open spaces. Finally, I made a super imposition exercise with some layers of heritage building data, robustness data of building structure, infrastructure data, and environmental degradation data. The final analysis produced a synthesis about the development of a design model for the Bogor Station area, which is TOD-based. The preliminary design modeling (model-Vo) was simulated and evaluated by experts, especially examined in terms of patterns of passengers’ behavior, and patterns of movement of goods and services. The results of evaluation and examination from experts were used to the next analysis, the next synthesis, and to rebuild the next variant modeling (model-V1). Then, the model-V1 was simulated and reevaluated, until it was found a model that was considered valid and feasible to be implemented in the Bogor Station area. The experimental method design process is illustrated (Figure 1).

![Figure 1. Experimental design process (Source: Achten, H.H, 2019) [10]](image-url)

4. Discussion

4.1. Overview of Bogor Station
Bogor station was located on Jl. Nyai Raja Permas Nu.1, Bogor City, near by Taman Topi, which was quite well known. This station was adjacent to Jl. Mayor Oking and Jl. Kapten Muslihat. The area of the station was approximately 34,000 square meters. Bogor station was one of the heritage stations protected by PT. KAI. The Bogor station building has been named as one of the cultural heritage protected by Bogor City Government. The colonial atmosphere still felt thick when walking through every corner of the room. Bogor station was divided into two buildings side by side. The main buildings were in the form of station entry areas, lobbies, administrative offices, tickets sales points and other facilities. The other building was a canopy building with a platform and two railways lines. The main building of the existing station inaugurated since 1881 and has not changed much until now.
The station’s architecture was European style with Indische Empire style nuances with a symmetrical mass of buildings with a main Neo-Classical entrance and lobby. At Bogor station there were several commuter line train routes which generally have 10 carriages, and near to the station there was another station, namely Paledang Station, which provided Bogor-Sukabumi travel routes, and vice versa.

4.2. Behavior Analysis: Image and Context of the Pedestrian Corridors

Image and context were an explanation of the description of the conditions and locations around the Bogor Station Area. Through image and context were explained and illustrated the impression when people pass through the road and the location of the attraction that was around the Bogor Station area. Image description and the context were divided into 8 winds as follows.

4.2.1 East. People were passing Jl. Nyi Raja Permas to Jl. Dewi Sartika felt safe because of many police on these roads. Street lights along these roads made pedestrians felt comfortable when passing these road at night. This road was only 400 meters from Bogor Station and the more it leads to the East there were restaurants, shops, etc. Everyday the impression of being busy and crowded was felt by pedestrians. These conditions were causing the traffic jams due to public transportation stopped at the side of the road, as well as the many commercial spaces attracted people to come on these places. In other hand, a number of trees and gardens made a beautiful and shady impression, and added beauty when walking into the east from Bogor station. Unfortunately, in the east direction there was still some dirty spots with a pungent smells.

4.2.2 Southeast. At the southeast direction from Bogor station was very crowded because there were commercial places that were on a large arterial road that many vehicles and humans pass by passing to Bogor station. Congestion was occurred due to the crowd. If you walk to the southeast, there were settlements that seem dirty. The settlements were traversed by small roads, and at the nighttime the light was not so bright and the road was giving the impression not safe to walk on this road. Along the small road there were many street vendors and made unorganized spatial impression. The lack of trees also made the road looked barren along commercial premises and slums residential areas.

Figure 2. Behavior Mapping of Bogor Station TOD Area (Source: Prasasti, Amelia, and Aulia, 2018) [11]
4.2.3 **South.** When pedestrians were walking from the Bogor station to the south direction, they must pass a pedestrian bridge that was quite high. The bridge was inaccessible to disabled and/or diffable people. Direct access to Jl Paledang in the south was temporarily closed. Many commercial trades and services area, and some heritage buildings were located there. The atmosphere was very busy in the morning until late afternoon, and the crowds caused traffic jams. The atmosphere of the road was full of activities of the street vendors in front of the Paledang Station. The train passengers of Paledang station were only crowded in the morning, evening and at night, especially when the schedule was departs and/or arrives. There were two residential areas which are separated by rivers and connected by a bridge. The condition of residential area was slum with minimal lighting at night. The condition of the bridge connecting two settlements was very aesthetic because the bridge was painted in attractive colors. However, lighting on the bridge was very minimal, giving an impression of being unsafe when crossing the bridge at night. Trees around the bridge made a leafy impression. The view of the river water under the bridge was dirty because of the large amount of garbage in the river.

4.2.4 **Southwest.** When I was walking via Jl. Mantarena, there were two images captured along this road. The first image that can be caught was a dirty, rather shabby and dimly lit environment along the first 150 meters. The number of street vendors selling on the side of the road along the banks was a market between the roads that were flanked by 2-story building so that the sunlight entering the building was blocked. In addition, road lighting infrastructure along this road was not yet available. While the second image that can be caught in the form of a healthy housing environment, densely populated, but neatly arranged.

4.2.5 **West.** When I walked towards the west through Jl. Raya Dramaga and Jl. Veteran, there were commercial shops on the Dutch colonial buildings. The impression of the old city was still very much felt. The function of the area as a commercial area made this road busy, both with people who came to shop, street vendors, and public vehicles that pass through this area. The condition was so crowded, because commercial activities in this region interfere with the use of roads. Many street vendors’ activities were carried out on the road, including informal parking lots. Public transportation stopped at any time while waiting, or picking up passengers made the area seem chaotic.

4.2.6 **Northwest.** The way out to the northwest area was Jl. Merdeka. Along this road the captured the form of an old commercial area because the building used was still the Dutch colonial buildings. However, in this region it was more organized compared to Jl. Veteran. Vehicle parking was carried out on the shoulder of the road regularly along this free road, even though users park their vehicles on pedestrian paths, so that they did not interfere with the use of the roads, but disturb pedestrians.

4.2.7 **North.** To able to walk to the north direction, pedestrians must go through Jl. Nyi Raja Permas which was dirty and irregular. This was due to the presence of vehicles parked carelessly in front of the shop, as well as the presence of street vendors on the East side of Jl. Nyai Raja Permas. In addition, the absence of pedestrians ways and the absence of adequate vegetation on this road caused inconvenience in walking. At the first 400 meter, there was Pasar Anyar, a large traditional market with many economic activities here. Passing through the Pasar Anyar, close to Jl. Moh A Salmun, there were many local trades everyday so the place became dirty and congestion. When I walked straight to the east I found a railroad doorstep. Around the crossbar there was a traditional market that impeded the flow of traffic. After the railway doorstep, to the north there was Jl. Moh A Salmun, then Jl. Ardio, which was a residential area.

4.2.8 **Northeast.** I passed Jl Dewi Sartika to walk to the northeast direction. The image of the area was crowded, irregular, hot and dirty with street vendors, wild parking, and old buildings in the neighborhood. Street vendors along 500 meter occupied the pedestrian ways west of Jl Dewi Sartika.
so that pedestrians were uncomfortable. Based on my research notes, from Jl Dewi Sartika went to the Northeast through Jl Gedong Sawah, there was a commercial area and settlement. When passing via this road, the impression of a view was slum and dirty, because there were street vendors who occupied the road. The road was quite small, if it was traversed by four-wheeled vehicles and also it has not adequate pedestrian ways so it was not convenient for their users. After 500 meter walk, there was a commercial area on the North as well as a government and education area on the South. The image of this road was chaotic, because the road usually was congested for the public transportation line number 01 with Cipinang-Gading route to Terminal Merdeka.

4.3. The Development Design Model

In the development design model for Bogor Station area there were several points that could change the existing land use and zoning. The changes followed the TOD concept and the TOD principle, as mentioned on 2.2. Principle, namely mixed-use urban design. In addition, the development of the TOD concept also paid attention to the RTRW and regulations contained in the city of Bogor, and paid attention to the existing conditions as well as the potential and constraints in the area around Bogor station. The concept of developing the Bogor Station TOD area was planned to build a mixed zone area or mixed-use at several points within a radius of 800 meters from Bogor station. The mixed zone was in the form of a combination of residential, green open spaces, commercial and offices, heritage buildings, and traditional market areas with bus stops, city terminals, Paledang station, including several attractiveness in order to create a TOD area that was comfortable and safe for pedestrians. The development design model was simulated and evaluated iteratively in many times upto a good response from the expert. The following was a description of the TOD concept development plan in the Bogor Station area, i.e.

1) Development of mixed zones or mixed use between stations, terminals, parking lots, office buildings, and commercial area, including the street vendors;
2) Flats will be connected by attachment building to mixed use;
3) Making a change point, sky bridge to Bogor station, making green open space, including children playground;
4) Making an underpass from the Bogor station to the Paledang station;
5) Maintaining the heritage architecture at the Bogor station.
5. Conclusions

The research conclusion was that it was found the development design model which was applying the TOD concept and has the design criteria, such as 1) the Bogor Station TOD area was an specific area needs to implement intensive land use zone and the heritage building zone; 2) the Bogor Station TOD area must own green open spaces with endemic vegetation characteristic and children playground facility; 3) the traditional markets that cause congestion and decline the environment quality need to be resolved; 4) transfer of passengers from Bogor station to Paledang station, and vice versa, as well as made safe and comfortable pedestrian corridors for disabled and diffable people need to be solved in detail engineering design; 5) the results would be donated to the Bogor City Government.

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