Transit oriented development of light rapid transit palembang

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Abstract. Light Rapid Transit (LRT) is one of the public mass transport which is necessary to break the problem of the urban transportation system in developing countries. LRT has many promises in the development of the city, in addition to solving the transportation problem is an increase in economic activity. This current case study of the paper is Palembang, one of the cities in Indonesia; the government develops mass public transport to solve the transportation problems. The government planned LRT construction to optimize the development of demand for public transport. This paper studies the concept of LRT construction by the development of Transit Oriented Development (TOD), include the development of estate management at stations area. The concept of Transit Oriented Development (TOD) for the develop stations location to spur the growth of economic activity around the locations. This concept needs to analyze the socio-economic impact study to determine the feasibility of developing TOD level especially at stations and the land use impact of the construction of LRT. Survey of Palembang City land use shown that 23 location can use as stations. The analysis by the impact of the socio-economic condition, land use, and feasibility of LRT construction; present that there are 13 locations can be used as TOD and shown as stations of Palembang LRT.

1. Introduction

The importance of an economic sector that requires a reliable, efficient, and effective transportation system. Effective transportation means that transportation systems that are compatible with capacity, connected or integrated with modes of transport, orderly, safe, convenient, precise, safe, secure, convenient and economically affordable. Efficient in the sense of community burden as the user of transportation service becomes low and has high utility.

In the context of the rapid economic growth in Palembang City, the demand for transportation increasing, so needed the appropriate mode to realize. From the last two years, the government trying to optimize the demand by developing light rail transit as a new mode to solve the problem.

The concept of development for transit-oriented must necessary to support the installation of light rail transit (LRT). Analysis of transit-oriented will be a great opportunity to investigate as research, since the Palembang light rail transit (PLRT) as the first LRT implementation in Indonesia. Transit-oriented development in PLRT will apply the concept of development of Transit Oriented Development (TOD).
Nowadays, TOD has become an increasingly popular planning idea [1]. Many arguments for pursuing TOD even though that are similar despite the different contexts [2]. Meanwhile, there is no single which all-encompassing definition that represents the TOD concept [3]. TOD facilitates increased accessibility because it provides alternatives to automobile-based land uses [2]. In that point of view, this study analysis about the development of TOD in PLRT, in which to analysis socio-economic condition, land use, and feasibility of LRT construction context to suggest TOD locations of PLRT and comparing with current stations. This research expected to make an effort for the success of integrated mode for future development of Palembang city. TOD will give the sustainable transit and benefits to users and government.

2. Research Literature

2.1. Transit-Oriented Development

Transit-oriented development (TOD) is a mixed-use residential or commercial area intended to maximize access to public transportation [4]. TOD formally refers to mixed-use, relatively intense development concentrated around the transit station in a 1/4- to 1/2- mi radius and oriented to transit riders with a pedestrian and cycle-friendly environment [4], [5]. TOD strategies also integrate land use and transport functions to aimed at urban sprawl [6].

Limited studies have examined localities plan for and implement transit-oriented projects [1]. Belzer & Allier (2002), mention that framework to use for planning and analysis of TOD projects as three main focus; a focus on the desired functional outcomes of TOD, not just physical characteristics, acknowledgment of a continuum of success, adaptation to different locations and situations. Planners identified three essential zoning strategies for TOD, they called as the ABC’s of TOD zoning, where is: (1) active pedestrian-friendly streets, (2) building intensity and scale, and (3) careful transit integration [4]. TOD planning can be adopted for new construction or redevelopment [6]. Holmes & Hemert (2008) mention that measures TOD potential for sustainability can be assessed by:

1. Income variance in TOD neighborhoods (the greater, the better)
2. Number of housing units nearest to transit stations (increasingly higher nearer station)
3. Percentage of person who living in TOD using transit
4. Increased income levels of TOD residents over a period
5. Harmony of mixed uses
6. Thriving enterprise in TOD communities

2.2. Challenges for Transit-Oriented Development

Generally, TOD can create a community more desirable for people to live and work in it [4]. TOD can be one of the approaches to developing an urban area that adopts mixed spatial layout and maximizes the use of mass transit. TOD’s provide unique benefits on a regional, local, and individual scale with overall planning, thus can promote local businesses and retail area, capture increased land values from public investment in new transit routes, and replace costly surface parking costs and associated automated infrastructure with usage that generates more revenue for local governments and businesses [4]. In reality, many projects fail to provide the full range of synergies and benefits of TOD are announced successes because there is no standard or criterion for success [7].

3. Methodology

The study method includes four parts: (a) review of the literature on the TOD experience in the selected cities; (b) data collection for supporting the analysis; (c) TOD analysis from socio-economics of Palembang City and land use that related to PLRT project; and (d) Evaluate the TOD of PLRT concept.

Evaluation for TOD of PLRT concepts are adopted with this measurement:

a. Socio-economic of the city [4], [6]

b. Origin-destination [3]
c. Mode used [8]
d. Land use and Facilities in TOD [3], [4]
e. Thriving enterprise in TOD [4]

In socio-economics analysis, influence factor support for deciding on TOD planning. The factors are a socio-economic area, the condition of transportation, potential locations for business development, and regulation. Data attraction and generation from survey assessed with correlated by linear regression method with socioeconomic parameters. The socio-economic parameter in this study are 1) population, 2) population growth, 3) education and 4) economic. Furthermore, the condition of transportation observed by identification of feeder mode, access, and infrastructure facilities. After that, selection of potential location with the possibility of business development and connect the assessment with regulation. Based on the linear regression method, correlation above generation and attraction with socio-economic parameter are used to origin-destination analysis. The socio-economic parameter used is population. Furthermore, analysis of mode in Palembang, analysis of land use facilities and a thriving enterprise in 23 TOD points by the survey. Hereafter, pursued the analysis results to obtain the best TOD and make a comparison with the planning of PLRT stations location.

To support this study conducted data retrieval in the form of primary and secondary data. Primary data is the most important and useful data in the study to get a proper review in solving the problem. Primary data retrieval with two methods of the survey; survey origin-destination and survey of land use. Secondary data collected by statistic data of Palembang city and government spatial plan of city and province.

Primary data collected at the end of 2015 before the installment of PLRT. Origin-destination (OD) survey conducted to analyze the types of people movements in 16 sub-district in Palembang city. To ease of analysis, Palembang city divided by zones which zone based on sub-district and narrowed it to four zones as seen in figure 1. OD Survey held in a week in October 2015 by home interview survey, this conducted before the PLRT installment to get the valid data. Furthermore, primary data collected by a survey of land use. This survey held during the research by analysis of Palembang spatial plan and observation of the current situation.

4. TOD Analysis

4.1. Analysis of Socio-economics

Population in Palembang City on the year 2010 to 2016 has increased with the average growth of 1.41% from 1,468,007 people in 2010 to 1,602,071 people in 2016 as seen in table 1. This number of growth level is relatively low compared to the growth of the South Sumatera Province population which are 1.85% per year but almost equal with the National Population Growth of Indonesia above 1.49% per year.

| No | Subdistrict | Population | Annual Population Growth Rate (%) |
|----|-------------|------------|-----------------------------------|
|    |             | 2010       | 2015     | 2016     | 2010-2016 | 2015-2016 |
| 1  | Ilir Barat II | 64,440     | 65,911   | 66,891   | 0.62      | 1.36      |
| 2  | Gandus      | 57,887     | 62,146   | 62,994   | 1.42      | 1.36      |
| 3  | Seberang Ulu I | 165,236   | 176,749  | 179,160  | 1.36      | 1.36      |
| 4  | Kertapati  | 81,014     | 84,698   | 85,853   | 0.97      | 1.36      |
| 5  | Seberang Ulu II | 94,227    | 99,222   | 100,575  | 1.09      | 1.36      |
| 6  | Plaju       | 79,809     | 81,891   | 83,008   | 0.66      | 1.36      |
| 7  | Ilir Barat I | 125,315    | 135,385  | 137,231  | 1.53      | 1.36      |
| 8  | Bukit Kecil | 43,892     | 43,967   | 44,567   | 0.25      | 1.36      |
| 9  | Ilir Timur I | 69,716     | 71,418   | 72,391   | 0.63      | 1.36      |

Table 1. The population of Palembang in 2010, 2015, and 2016 [9]
The number of people in Palembang in 2016 is 1,602,071 with an average density rate of 3,999.08 people per km² as seen in table 2. With such large population size, in 2016 Palembang ranks number 9 in Indonesia regarding population, namely after Jakarta, Surabaya, Bandung, Bekasi, Medan, Semarang, Tangerang, and Depok [10]. The rank number of 5 larger density in Palembang is Ilir Timur I, Ilir Barat II, Seberang Ulu I, Kemuning, and Seberang Ulu II. Those subdistrict located in screen line of Palembang as shown in figure 1.

| No | Subdistrict     | Dimension Km² | Population Amount | Density People/Km² |
|----|-----------------|----------------|-------------------|--------------------|
| 1  | Ilir Barat II   | 6.22           | 66,891            | 10,754.18          |
| 2  | Gandus         | 68.78          | 62,994            | 915.88             |
| 3  | Seberang Ulu I | 17.44          | 179,160           | 10,272.94          |
| 4  | Keratapi      | 42.56          | 85,853            | 2,017.22           |
| 5  | Seberang Ulu II| 10.69          | 100,575           | 9,408.33           |
| 6  | Plaju         | 15.17          | 83,008            | 5,471.85           |
| 7  | Ilir Barat I   | 19.77          | 137,231           | 6,941.38           |
| 8  | Bukit Kecil    | 9.92           | 44,567            | 4,492.64           |
| 9  | Ilir Timur I   | 6.50           | 72,391            | 11,137.08          |
| 10 | Kemuning       | 9.00           | 86,161            | 9,573.44           |
| 11 | Ilir Timur II  | 25.58          | 167,491           | 6,547.73           |
| 12 | Kalidoni      | 27.92          | 112,495           | 4,029.19           |
| 13 | Sako           | 18.04          | 92,329            | 5,118.02           |
| 14 | Sematang Borang| 51.46          | 37,945            | 737.38             |
| 15 | Sukarame       | 36.98          | 166,378           | 4,499.13           |
| 16 | Alang-alang Lebar | 34.58       | 106,602           | 3,082.68           |

Total 400.61 100 1,602,071 100 3,999.08

From Population data, projected using linear regression with base data of origin-destination matrix by data collection. Data collection was provided in 2015 before construction of PLRT start to get the valid data about origin-destination without any due to construction impact. Furthermore, prediction of inter-zone movement in Palembang can be formed in matrix of origin-destination with growth factor model.

4.2. Analysis of Origin-Destination
Correlation analysis was present to assess the relationship between the dependent and independent variable. Population data used as an independent variable to projected using linear regression with Origin-destination data. The data showed that most of origin-destination in Palembang are short distances and inter-zone trips. Based on the origin-destination data, most of the trip in a screen line of Palembang which is shown in figure 1.
Table 3. Matrix Origin-destination of Palembang in 2015

| ORIGIN | Zona 1 | Zona 2 | Zona 3 | Zona 4 | TOTAL  |
|--------|--------|--------|--------|--------|--------|
| Zona 1 | 1655   | 3310   | 2178   | 174    | 7317   |
| Zona 2 | 610    | 25436  | 11237  | 871    | 38154  |
| Zona 3 | 261    | 5749   | 10192  | 1132   | 17335  |
| Zona 4 | 0      | 1829   | 6098   | 12370  | 20296  |
| TOTAL  | 2526   | 36325  | 29704  | 14547  | 83102  |

Furthermore, the new matrix provides with four-zone as shown in Table 1. This allocation of the zone to analyze the trips and determine the TOD location for PLRT. The four-zone provide based on socio-economic data which present before.

From the table 3 shown that total trips in Palembang about 83102 trips per day, with inter-zone trips are the most trips that prevail in.

Figure 1. Study Zoning Base

4.3. Analysis of Mode-Used

To see the use of modes based on the origin of the destination and to estimate the number of passengers, the city of Palembang is divided based on the four zones. Four zones were analyzed the number of modes of use to obtain the destination matrix based on the mode and origin based on as shown in this following table.

From the data of matrix origin-destination and mode, shown that zone 2 and zone 3 more high than another zone. Taxi bike and motorcycle are the most popular mode that used in Palembang. Otherwise, this table shows that most of the people in Palembang using motorcycle and private car for their daily routine activity. PLRT will give the new effect of Palembang residents by using a new mode of
transportation. This mode is expected to reduce the using of private vehicles and give the effective benefit of the mass transit system. Furthermore, based on this analysis which shown the highest of origin-destination in zone 2 and zone 3, it means that most of TOD locations will be in that zones.

Table 4. Matrix Destination-Mode 2018

| OD | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | TOTAL |
|----|----|----|----|----|----|----|----|----|----|-------|
| Zona 1 | 3310 | 174 | 0 | 8130 | 7695 | 145 | 145 | 436 | 2178 | 0 22213 |
| Zona 2 | 47997 | 784 | 436 | 121082 | 122534 | 15389 | 1887 | 8275 | 28311 | 436 347131 |
| Zona 3 | 68816 | 1742 | 1742 | 121082 | 111645 | 13647 | 5807 | 9146 | 64025 | 1307 398961 |
| Zona 4 | 42858 | 1132 | 1742 | 60396 | 48781 | 1597 | 1597 | 1742 | 15244 | 436 175525 |
| TOTAL | 102982 | 3833 | 3920 | 310690 | 290655 | 30779 | 9437 | 19000 | 109758 | 2178 943829 |

1: walk, 2: bicycle, 3: boat, 4: taxi bike, 5: motorcycle, 6: TransMusi, 7: paratransit, 8: taxi, 9: private car, 10: bus.

Table 5. Matrix Origin-Mode 2018

| OD | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | TOTAL |
|----|----|----|----|----|----|----|----|----|----|-------|
| Zona 1 | 6561 | 7 | 436 | 22358 | 21903 | 191 | 37 | 1307 | 4791 | 0 57591 |
| Zona 2 | 42335 | 348 | 0 | 79850 | 76221 | 4936 | 1452 | 8711 | 37893 | 0 251746 |
| Zona 3 | 22823 | 261 | 0 | 29617 | 28346 | 1742 | 871 | 3049 | 12631 | 436 100170 |
| Zona 4 | 29617 | 1307 | 1307 | 45878 | 34844 | 4501 | 2323 | 1307 | 12631 | 2613 136326 |
| TOTAL | 101336 | 1923 | 1742 | 177703 | 161714 | 11370 | 4683 | 14373 | 67945 | 3049 545838 |

1: walk, 2: bicycle, 3: boat, 4: taxi bike, 5: motorcycle, 6: TransMusi, 7: paratransit, 8: taxi, 9: private car, 10: bus.

4.4. Analysis of Land Use and Thriving Enterprise
To see the use of modes based on the origin of destination and to estimate the number of Based on the Government Palembang Spatial Plan, origin-destination analysis, mode-used analysis, and land use data; there are 23 locations suitable for TOD location. Thus are 3 locations in zone 1, 7 locations in zone 2, 8 locations in zone 3, and 5 locations in zone 4. The Strategic location area for TOD location in table 6 shown current land use from the survey and future land use from Government Palembang Spatial Plan.

Table 6. TOD Strategic Area Analysis

| No | TOD Location | Current land use | Future land use development | Problems |
|----|--------------|------------------|-----------------------------|---------|
|    |              |                  | Current (before PLRT install) | Future (after PLRT install) |
| 1  | SMB II Airport Housing & Industrial area | Housing & Industrial area | Development area adjust by airport masterplan | Connection with airport |
| 2  | Auto2000 Housing & Industrial area | Housing & Industrial area | Undeveloped suburbs | Existing mode as feeder & change of route |
| No. | Location          | Category                        | Existing Mode                                      |
|-----|-------------------|---------------------------------|----------------------------------------------------|
| 3   | Hajj Dormitory    | Housing & Industrial area       | Existing mode as feeder & change of route          |
| 4   | Dolog             | Housing & Industrial area       | Existing mode as feeder & change of route          |
| 5   | Damri             | Housing & Industrial area       | Existing mode as feeder & change of route          |
| 6   | JM Sukarami       | Housing & Industrial area       | Existing mode as feeder & change of route          |
| 7   | Telkom            | Housing & Industrial area       | Existing mode as feeder & change of route          |
| 8   | Punti Kayu        | Housing & city forest           | Trip attraction area and densely populated area    |
| 9   | South Sumatera    | Housing & Industrial area       | CBD Trip attraction area and densely populated area |
|     | Province Hospital |                                 |                                                    |
| 10  | KM5 Market        | Housing & retail area           | CBD Trip attraction area and densely populated area |
| 11  | Polda Intersection| Housing & retail area           | CBD Trip attraction area and densely populated area |
| 12  | Angkatan 45       | Housing & retail area           | CBD Trip attraction area and densely populated area |
| 13  | Palembang Square Mall | Retail area | CBD Trip attraction area and densely populated area |
| 14  | A. Rivai Road     | Offices                         | CBD Trip attraction area and densely populated area |
| 15  | Cinde Traditional Market | Retail area | CBD Trip attraction area and densely populated area |
| 16  | International Plaza | Retail area | CBD Trip attraction area and densely populated area |
| 17  | Grand Mosque      | Retail area                     | CBD Trip attraction area and densely populated area |
|     |                   |                                 | Integration PLRT with Integration PLRT with TransMusi Bus and TransMusi fleet |
4.5. TOD Evaluation

Furthermore, analysis of TOD location and selection of PLRT station location based on current land use, attraction and generation area, feeder, and mode integration. PLRT station must integrate with an understanding of this basic following:

a. Connectivity: integrated doesn’t simply mean that it is a collection or connection between identical modes. Integrated also means that there is a connection between motor engined vehicles and train. In addition, integrated also means connecting stations to ease the movement of passengers.

b. Comfort; Integrated means that passengers do not have to exit the station and take pains (face social risks) while moving between routes in their pursuit of comfort.

Figure 2. PLRT Station and TOD Location Design
c. Accessibility: Integrated regarding distance and easy to access infrastructure, for example, the provincial roads and LRT way must integrate, the bus terminals and stations not far apart. Other transportation modes from outside or inside the city can also easily access the PLRT mode.

d. Convenience: Integrated means that the public facility and infrastructure is well maintained and prepared, for example, a good pavement, road shoulder, bicycle track according to the standard required (if necessary, inadequate local regulations should be revised). Service also includes good scheduling of between transportation modes.

e. Integrated with public infrastructures such as open green areas (parks around the stations, parking lots, and city order (commercials, residences, and trade centers) in a certain radius.

Based on five and analysis, 13 locations selected which are: SMB II Airport, Hajj Dormitory, Telkom, South Sumatera Province Hospital, Polda Intersection, Angkatan 45 Intersection, Palembang
Square Mall, A. rivai Road, Cinde Traditional Market, Ampera Bridge, Jakabaring Intersection, Jakabaring Stadium, and OPI Mall. This location was chosen by selecting station locations and integrating with evaluation from the analysis. Thus, the chosen TOD locations must include:

a. Analysis of demand, namely based on busy spots in the city and centers of movement. On the selected spots, identification of development plan must be made or alternative development to become a transportation mode solution.

b. Must exist every 2 to 4 km, to make a development spread planning that transforms PLRT into a transportation backbone in the future of Palembang City.

c. Spots with TransMusi stations or other stops must be prioritized, integrating Trans Musi with PLRT thus is suitable with the principles of Integrated Transportation as explained before.

d. Spots necessary such as mall, important places (sport, worship, event, etc) and integrated shopping spots and Public Service Centers.

The 13 locations of TOD are similar to PLRT station, only two locations are different which are Palembang Square Mall and Jakabaring Intersection. Those locations near the installation of PLRT stations as shown in figure 2.

5. Conclusion

The TOD idea is a comprehensive effort for using the planning of land use to support transit rail system [1]. TOD concept provides the referrals for transit planning which adjusted with land use thriving enterprise of the area. This concept gives sense very feasible to use to determine a suitable location for transit, especially for the mass rapid rail system. As the developing city, Palembang gets an opportunity as the first city has implemented LRT in Indonesia. The concept of PLRT planning should integrate with many aspects, neither modes but also the transit facilities. The better city planning always based on their transportation planning. It makes TOD concept being the best option to analyze transit system in Palembang. Furthermore, TOD also makes other chance for some area to develop especially suburbs area of Palembang city.

The results of this study suggest 13 locations of TOD for PLRT stations based on connectivity, comfort, accessibility, and convenience of Palembang people and especially the users of PLRT. The locations are quite similar with installment locations of PLRT stations. From analysis shown that TOD locations need integrations planning with other modes in Palembang city. The success of integrated planning with another mode will make a good effort to the future development of Palembang city.

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