Development of Urban Transportation System Based on Bus Rapid Transit

(Study Case : Kendari City, South East Sulawesi Province, Indonesia)

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Abstract

Urban transport systems in Indonesia have been influenced by kinds of traffic problems such as congestion, high accident rates and traffic violations and uncomfortable, safe, and orderly levels of public transport services. To develop urban transportation systems, a policy implementation is needed in public transportation such as special lanes for Bus Rapid Transit (BRT) as one of the alternative solutions to give better services for the public transport user.

The purpose of this study is to count the demand of bus rapid transit, determine number of corridors and halte for the BRT as well as know the types of BRT which should be operated in Kendari City in accordance with the needs of public transport users. The method used in this study is the quantitative method by collecting primary and secondary data which includes OD Matrix of destination of the population travel, Number of Passengers up and down on each route, Load factor in each route, Travel time and Road Inventory Data. Other data include Road length, Road width, Road type, width of trotoar, width of median, and Road Pavement type.

The results of this research is that the number of demand for public transportation in Kendari City are 28 buses with 8 units in the first corridor, 6 units in the second corridor, 8 units in the third corridor, and 6 units in the fourth corridor. Indeed, the total number of corridors needed to operated of BRT in Kendari requires 174 shelters. The potential population in Kendari City is categorized on the modest development and the existing conditions of the road, which is not too large for the BRT line planned. Therefore, the possibility of increasing the number of passengers then the type of bus which may be used as a fleet of BRT at the beginning of the operation is large floor buses total capacity of 79 people consisting of 49 seated passengers and 30 passengers standing.

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1. Introduction

Urban transport systems in Indonesia have been influenced by kinds of traffic problems such as congestion, rising of trip demands, lack of traffic discipline, dominance of private vehicles, inconsistency to develop land-use system, use of roads that are not fit to their function, the public transport service is not good, low accessibility, long trip time, discomfort and lack of safety in public transport, and the cost is high. Urban areas in Kendari City have problematic transportation systems like the other urban areas in Indonesia. The quick changes of land-use system have not been anticipated through the arrangement of good transport system; the operation of public transport services is still focused on certain roads causing some roads to be congested.

Public transportation is very limited and does not have a fixed schedule or fixed bus stops causing the accumulation of vehicles at one point in the road during certain hours. Besides that, the dominance of small capacity public transport (pete-pete) causes many problems, especially its impact on traffic smoothness such as service levels are low, uncomfortable, and low accessibility and lack of good public transport services (pete-pete). This is indicated by the increased congestion and reduced levels of service roads (V / C ratio) of 0.36 to 0.78 or traffic conditions that could potentially delay to congestion (Putra, 2006).

Urban transport system requires a planning policy implementation in the urban public transport system. The development of mass transportation such as Bus Rapid Transit (BRT) is very important to be prepared by the city government as one of the alternative solutions to problems of transportation to reduce the dependence of urban communities on private vehicles or small capacity of public transportation. The development of mass public transportation is an effort to give service priority to users of public transport so that public transportation would be more appealing. By reducing the use of private transport, congestion and traffic on highways will be reduced.

Small Capacity public transportation in Kendari City (pete-pete) is regarded as one of the causes of the problems of transportation systems. Development of Bus Rapid Transit (BRT) can improve the quality of public transportation services. this is in accordance with the mandate of Law Number 22 of 2009 about Traffic and Transportation in article 158 paragraph (1) stating that the government guarantees the availability of mass transit-based ways to fulfill the needs of people by providing common motor vehicles in urban areas. Given the problems and the current condition of public transport systems as mentioned above, it is necessary to develop urban transport systems based on Bus Rapid Transit (BRT) in Kendari City.

2. Literature Review

2.1. Urban Transportation System

Urban transportation systems have an important role in enhancing the economic development of society toward the development of an area (Murray, 2001). The transportation system is a system to perform a movement from one place to another place. We need a transport system in the implementation of planning techniques to develop an optimal strategy in the provision of facilities and infrastructure of urban transportation systems (Morlok, 1991).

Urban transportation systems have consequences for the social dimension such as welfare and justice for the people (Ahmed et al., 2008; Kenyon et al., 2002). Good function of transportation system properly is a factor that pushed for the development of community activities. Transportation provides movement access to the center of trade, education and housing. Inappropriate Strategy and program to develop the transportation system can damage the land use, environment and the capacity of the public space. Ineffective network services will not be able to fulfill the expectations of users of public transportation (World Bank, 1996). The transportation system in urban areas is related to the concentration of people and socio-economic activities of the population (Loo and Chow, 2006).

Urban transportation systems of developing countries emphasized on the development of a sustainable transportation system. UNFPA (1999), 95% of formation of human activities in the period 2000 to 2030 will occur in urban areas in developing countries. IEA (2008), the growth of in urban areas forms a pattern of global energy use and impact on the urban transportatin system. Urban areas need infrastructure of transportation for the movement of the population. Hall and Pfeiffer (2000), the cities of developing countries will face a lot of problems of transportation system that impact traffic congestion and accidents (death and injury). Urban transportation systems have various problems such as the low level of service, discomfort and unsafety (Pucher et al., 2005).

Urban transportation systems have challenges in making policies based on the potential of the region by prioritize to the economic growth, environmental preservation and prosperity of the present generation and the generations in the future (Zietsman and Rilett, 2001). The main priority is revamping the urban transportation system emphasized on the issue of the effectiveness of public transportation services as it will have an impact on the urban environment and the opportunity for the community to improve its quality of life (Holden and Norland, 2005). Planning of urban transportation systems requires the integration of environmental and the social economics of the population and it also needs the right strategy to improve the transportation system, particularly the aspects of security, comfort and arranging the land use (Schileer et al., 2010). Yao (2007) in his research explained that the
demand for public transport system based on a potential area by using characteristic variables of urban areas as well as land-use system.

2.2. Mass Transportation Development

Mass transportation systems can provide quality service and the main factor of mass transportation concept includes high quality infrastructure, efficient operations, effective and transparent institutional systems, advanced technology, and excellent marketing and customer service. Mass transportation systems such as BRT have been developed in several cities such as Bogota (Colombia) and Curitiba (Brazil). The BRT system that is also applied in developing countries includes Guayaquil (Ecuador), Jakarta (Indonesia), Pereira (Colombia), Brisbane (Australia), Ottawa (Canada) and Rouen (France). Mass transportation systems in about 40 cities on six continents have implemented BRT system, one of the cities that successfully implemented the BRT system is TransMilenio. The success of TransMilenio influenced by the government's capacity in the planning and design the transportation modes use very good technology, good corporate management, well-planned investments in infrastructure, and well-defined ticketing systems (Wright and Fjellstrom, 2003).

The development of urban mass transportation needs policies that consider many aspects such as planning, financing, ownership of vehicles and so on. One important aspect needed to develop an interesting mass transportation system is the analysis of the loss/profit of mass transportation, whether the system will improve or worsen the urban transportation system. The development of a mass transportation system is seen as an effective way to improve the quality of public transportation services in urban areas. Market competition will require service providers to provide products with an efficient transportation system oriented towards the public (Echeverry et al., 2005). The development of mass transportation leads to higher investments and greater revenues into the market. The income can replace government subsidies, but the investments in mass transportation is difficult to make a profit (Mees and Paul, 2005). Different demands of various groups participated influence policy-making, the development of mass transportation in urban areas have forced by particular group, so that the development of mass transportation is not efficient (Bianco and Martha, 1999). The central government is too focused on paying attention to cost reduction rather than improve services in the public transportation service system (White, 1997). The ability to improve public transportation services is a challenge for all stakeholders involved in the policy making of the transportation systems. The government becomes an effective tool to organize mass transportation. Some transportation systems have emerged such as the bus system Transmilenio in Bogota that is controlled by the public sector yet operated by the private sector. Even though some problems with these systems have been observed, the public/private form has been used in many developing countries (Echeverry et al., 2005).

3. Methods

3.1 Data Collection and Compilation

1) Secondary Data
   Secondary data is data obtained from several government agencies with regard to the data needed in transportation planning. Government agencies include:
   - Department of Transportation in Kendari
   - Regional Planning Agency
   - Police
   - General Research Department
   - Statistics Agency

2) Primary Data
   Primary data is data obtained directly with the aim to determine the existing conditions to formulate proposals the point of bus stop. Primary data needed include:
   - Data of the number up and down the passenger
   - Data of household interviews (Home Interview)
   - Data of willingness to change from private transportation to public transportation
   - Data of Road Inventory

3.2 Data Collection Methods
   To get the data as mentioned previously, the data collection was carried out in various ways including
   - Secondary data: get the contact to the related institutions to request the required data;
   - Primary data is conducted using surveys such as Dynamic Survey, Passengers Interview Survey, Household Interview Survey, Road Inventory Survey

3.3 Data Collection
   To clarify the primary data collection techniques, they will be explained below:
   1) Dynamic Survey
Dynamic Survey is a survey in public transportation vehicles to determine the number of passengers up and down on the route which is divided into several segments. The methods used in this survey include:
- Record number of passengers up and down
- Record time of trip in each segment
A dynamic survey was carried out in two days on duty (not on holidays). There were a number of observations carried out on at least six (6) round trips during the morning rush, six (6) round trips during hours that are not considered busy time and 6 (six) round trip in the afternoon during rush hours for each route observed.

2) Household Interview Survey
Household interview survey is a survey to interview the residents of Kendari City with a predetermined number of samples. The sample is determined based on the amount of each different zone in accordance with the existing population in the zone.

3) Roads Inventory Survey
This survey was conducted by recording the dimensions of the road. The collected data includes:
- Length of the road
- Width of the road
- Road type
- Width of sidewalk
- Width of median
- Pavement of the road
The survey was carried out across the street in Kendari City, this data supports Bus Rapid Transit in Kendari. With this data, we can determine which path is suitable for the Bus Rapid Transit and the width of the sidewalk data is also necessary to plan the construction of the bus stop.

3.4 Compilation and Analysis of Data
Compilation of data is data collection of primary and secondary data obtained from the surveys that have been conducted. Compilation and analysis of data are used to facilitate the process of analysis to be carried out in the Bus Rapid Transit plan.

- 1. OD Matrix in Kendari City
- 2. OD Matrix in Kendari City to community who use public transport;
- 3. Number up and down passengers on each route;
- 4. Load dynamic factor in each route;
- 5. Trip time;
- 6. Road inventory data;
Information from the data analysis includes:
- Route of Bus Rapid Transit;
- Type of BRT Bus;
- Number of bus stops on route/Corridor of Bus Rapid Transit;

4. Results and Discussion
4.1. Physical Condition of Kendari City
1) Geographic Conditions
Kendari city has a land area of 295.89 km2 or 0.70 percent of the land area of Southeast Sulawesi province. The total area of each district is very diverse. District of Abeli is the most extensive district region (16.77%), followed by the district of Baruga (16.76%), district of Poasia (14.71%), district of Puuwatu (14.43%), district of Mandonga (7.89%), district of Kambu (7.82%), district of West Kendari (7.77%), district of Kendari (6.61%), district of Wua-Wua (4.17%), and the district of Kadia (3.08%)
Kendari is the capital city of Southeast Sulawesi province astronomically located in the south of the equator among 3° 54′ 11″ - 30′ - 4° 3′ south latitude and stretches from west to east between 39° 23′ - 122° 122′ east longitude.
2) Population Condition
In 2016, the population of the city of Kendari ± 295,732 people spread in 10 districts and 64 sub-districts. The overall population each year has increased 1.99% (according to the Civil Registry). Size of Kendari is 295.89 km² and the population density is 999.466 inhabitants per-km². The population density each year has increased together with population growth.

3) Transportation Conditions
a. Road Network Condition
Good road conditions will facilitate the mobility of people and facilitate transportation to move goods to other economic and social activities. Conversely, when road conditions are less good, people will have difficulty in relationships of economic activity and other activities. In 2016, for the length of streets in Kendari city, there are 38 percent in good condition, 30 percent moderate condition, 25 percent in a damaged condition, and 7 percent in severely damaged condition.

b. Public Transportation
The public transportation service in Kendari City consists of City Transportation has 9 already existing routes and 3 routes that are in the planning phase but are approved by the mayor of Kendari but are not functioning optimally yet. The type of vehicle used is a type of Public Passenger Car which has a capacity of 12 people.

c. Public Transportation Infrastructure
Good public transport infrastructure supports the performance of public transportation in a city. The right public transportation facilities will increase public transportation services such as right location of bus stops and strategic location of terminals. Other facilities such as departure information board are very important for passengers in using public transportation.

4.2. Data Collection Results
1) Determination of Traffic Zone
The determination of traffic zones in Kendari city is based on land use maps in Kendari City. The area has been divided into internal zones and external zones. Kendari city is divided into 33 internal zones, 3 special zones and 5 external zones. The following map of Kendari City Road Network and Zone Map is determined based on the terms zoning:
2) Data Collection
a. Land Use Survey

Land use is a condition of land use in the study area. In the study area there are a variety of land uses such as tourist areas, educational areas, residential areas, office areas, plantations, agriculture, and others. For residential areas in Kendari, the largest population is living in the Kendari Barat District. In the book of Kendari, 2016 recorded that the largest land user in Kendari which amounted to 23.52% or 6959 hectares of 29859 hectares of land in Kendari used as the building, then the second largest used as a garden which is equal to 16.86% or 4990 hectares. Land Use Conditions in Kendari city influence the transportation system in the city, because land-use influences the accessibility or convenience of the public to reach places that provide their needs. The following is a map of Kendari Land use:

It can be seen from the land use maps above that Kendari city is mostly covered in scattered housing. For areas that are farther to the center of town, the distance between one house to another house is relatively far such as the sub-district Bungokotoko, Abeli, Mata and others.
b. Household Interview Survey (Home Interview)

Household interview surveys were conducted in each and every zone with a predetermined number of samples. Surveyors collect the information based on a list of questions that had been prepared about the state of the family and its occupants trips in a certain period. All the residents of the house were directly questioned. The data collected should include:

1. Households data
2. Data on household members
3. Data of the regular trips by occupants

Household data and household members are data that associated with the address, number of occupants, the number of vehicles owned, family income, age, gender, location of work, the location of schools / education.

Data of trips that was collected is data of trip for each member of the family, schedule of trip, trip destination, and mode of transportation used.

4.3 Result of Data Analysis

1) Generation and Attraction of Trip (Base on Result of Home Interview)

The generation of the trip is the number of trips of each zone in the area of research, which is the journey by each member of the family in any internal zone.

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<th>Zone</th>
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<th>Person</th>
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Source: Results of Analysis

Total of the trip resulting from the matrix of origin-destination in the form of the trip amount of 382 398 population trip/person/day

Table 1, from Table Matrix Origin-Destination we can get information about the distribution of the trip in each zone and the largest trip distribution was obtained from zone 2 to zone 1 with the number of trips being 3,776 persons per day because the first zone is CBD (Central Business District) area with the characteristics of trade, services, and government so giving rise to the journey towards the zone 1 or commonly called the attraction of the trip.

From the table above it can be concluded that:

a) The number of the largest generation of trip contained in zone 1 was 40.210 trips person per day, because the zone 1 is the area of trade, services, government and residential areas.

b) Smallest generation of the trip is in zone 9 of 5.101 trip person per day which is a residential area that is far from the center of the city.

c) The number of the largest attraction trip contained in zone 1 of 35.838 trips person per day. This is because of the zone 1 as Center Central Business District (CBD).

d) The smallest attraction of the trip is in the zone 31 of 3.252 trips person per day because the area is a residential area that is predominantly fishermen that is located relatively far from the city center. Besides that, land use of zone 31 is mostly empty land.

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From the analysis of generation and attraction of trip in each zone, the obtained map of Kendari Desire Line in the image below. The desire line shows the black bars indicating the number of trips taken, the thick line shows that the higher rate of trip. Base on Kendari desire line can be seen trip from zone 2 and zone 1 has a high rate of trip. Meaning of trip generated by the zone 2 and zone 1 has a high level of generation of trip to another zone.

Figure 5. Map of Desire Line

4.4 Corridor of BRT In City Kendari
1) Corridor I

2) Corridor II
City Central Market - Jl. Pembangunan - Jl. Dr. Sutomo - Jl. Ir. Hj. Alala - Jl. Edi Sabara - Jl. Brigjend Soegiarto - Jl. Malaka - Jl. Bunggasi - Jl. Haji Banawula - Terminal Lapulu. the path taken is ± 16706.81 m. Figure below shows BRT Corridor II (Green color line)

3) Corridor III
Port Bungkutoko - Jl. Haji Banawula - Police Abeli - Jl. Imam Bonjol - Faculty ITK - Police Sultra - Jl. Haluoleo - Jl. Boulevard - Jl. Capt. P. Tendean - Jl. Robert W. Monginsidi - Airport Haluoleo. The length of the path taken is ± 34 627 m. The figure below shows BRT Corridor III (Blue color Line)

4) Corridor IV

5) Corridor Intersection
Picture map below shows the intersection of the Corridor I, Corridor II, Corridor III and Corridor IV of BRT Kendari. The following location of four corridors intersection:
1. Intersection of Corridor I (purple line) and Corridor IV (black bars) is at the office of State Electricity Company on Jl. Mayjend D. Pandjaitan;
2. Intersection of Corridor I (purple line), Corridor III (blue line) and Corridor IV (black bars) is at the junction round of Baruga;
3. Intersection of Corridor II (green line) and Corridor III (blue line) is at the traditional market of Lapulu.

Picture below is a picture of the intersection of the four corridors.
4.5 Location of Bus Stop
Bus stops are public transportation stops building for lowering and/or raising the passengers.

1) Corridor I
From the results of the study with regard landmarks around the road to be traversed BRT in Kendari Corridor I ± 30,251 m, number of bus stop location as many as 39 (thirty-nine) are placed on the right and left of the road for the total amount to 78 (seven twenty-eight) bus stop on Corridor I.

2) Corridor II
Corridor II ± 16706.81 m, number of bus stop location as many as 20 (twenty) are placed on the right side and left of the road for the total amount to 40 (forty) bus stop on Corridor II.

3) Corridor III
Corridor III ± 34 627 m, number of bus stop location as many as 15 (fifteen) were placed on the right and left of the road for the total amount to 30 (thirty) bus stop on Corridor III.

4) Corridor IV
Corridor IV ± 25 139 m, number of bus stop location 13 (thirteen) were placed on the right and left of the road for the total amounted to 26 (twenty-six) bus stop on Corridor IV.

5. Conclusions
Based on the results of the discussion, it can be concluded as follows:

1) The number of public transportation requires in Kendari City is as much as 28 bus. 8 units Bus for corridor I, 6 units Bus for corridor II, 8 units Bus for corridor III and 6 units bus for corridor IV.

2) This bus operation is divided into four corridors:

3) The potential population in Kendari City is categorized on the modest development and the existing conditions of the road is not too large for the BRT line planned. So, the possibility of increasing the number of passengers then the type of bus which may be used as a fleet of BRT at the beginning of the operation is large floor buses total capacity of 79 people consisting of 49 seated passengers and 30 passengers standing.

4) Number of the bus stop for Bus Rapid Transit in Kendari: Corridor I = 78 units, Corridor II = 40 units, Corridor III = 30 units, Corridor IV = 26 units.
References