MATEC Web of Conferences **58**, 02002 (2016) DOI: 10.1051/matecconf/20165802002
BISSTECH 2015

ACCESSIBILITY TO PUBLIC TRANSPORT SERVICES (CASE STUDY OF TABANAN REGION, BALI-INDONESIA)

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ABSTRACT

Motorization is becoming an issue of concerns for urban governments and citizens in Indonesian cities, including in Bali Province. The cities in Bali Province have not been served well by public transport services. Bali consists of 9 regions and this study focused on a typical low income region in Bali i.e. Tabanan Region as a case study. One way to measure public transport service quality is by measuring accessibility to public transport routes. The objective of this study is to investigate the accessibility of residents to public transport services in Tabanan Region. Accessibility to public transport services in Tabanan Region was analyzed based on travel distance and travel time to reach the closest public transport routes. Based on Z-score diagram, it was found that six zones were in quadrant A which means that these zones were in high accessibility category (Bongan, Gubug, DauhPeken, DelodPeken, DajanPeken and Denbatas. On the other hand, five zones were identified in quadrant D. These zones (Sudimara, Subamia, Buahan, Tunjuk and Wanasari) have a low accessibility values to reach public transport routes. Therefore, improvement of infrastructures and public transport services need to prioritize these five zones with low accessibility values.

Keywords: accessibility, public transport, travel time, distance, Z-score

INTRODUCTION

Rapid growth of motor vehicles has been experienced by many cities. Motorization is increasing rapidly in Indonesia. The increase of population and economic has been followed by the increase of the number of motor vehicles. Motor vehicle increases mobility and improved accessibility particularly in rural areas. However, the growth of motorization has caused negative impacts such as increases traffic jam, air pollution, traffic noise and accidents.

Many researches have been focused on the impacts of motorization and urbanization (for example, see Newman and Kenworthy, 1999; Kitamura, et al., 2003; Joewono, et al., 2013). In sparsely populated area, car is valued as the most optimal mode for commuting (Sandow and Westlin, 2010). Unlike the developed countries, most developing countries are not served by proper mass public transport system. Low public transport services have caused a high increase in the use of private car. Sprawling development without being served by a good public transport system has caused the increasing dependency on the use of motor vehicles among urban residents in developing countries. Residents in a city have become highly dependent on the use of private motor vehicles. This rapid growth of motor vehicles has made the whole transport system become overloaded, thus obstructing the mobility. This high motor vehicle's ownership has caused a high increase in energy consumption and air pollution. From the view point of global warming effects, this motorization will cause serious problems. Therefore, recent transport policies in some developing Asian countries have started to focus on raising public awareness about sustainable transport dan promoting public transport use (Pardo, 2006). A serious action to reduce our dependency on motor vehicles is required, otherwise the urban environment will deteriorate in the future.

The increase in the use of private motor vehicles is also related to the land use planning in a city. Urban sprawl and decline in the city centers have been experienced by many Asian cities including Indonesia. In many cities, such as Bangkok, Manila and other major cities, urban redevelopment plans were introduced by promoting better public transport planning. The target of sustainable city is to create a sustainable and low-carbon society through the urban redevelopment (Kikuchi, et al., 2011). According to Yu, et al. (2011), there is a tendency of increasing energy consumption in the Asian region. They stated that since 1990, the energy consumption has increased by two thirds, which is mainly caused by middle-income countries such as China and India. They predicted that the increase of energy consumption in Asia is estimated to account for 46% in the total world energy increase in the year 2030.

Several studies have investigated the behavior of people towards the use of public transport. Sekar, et.al. (2015) investigated the most preferred mode from three types of public transport, i.e. metrorail, monorail and bus rapid transit in 19 cities. By applying Markov Chain Process and Analytical Hierarchy Process they found that metrorail is the best mode. Lay and Chen (2011) stated that public transit service quality influences the behavioral intentions of public transit passengers. In a similar study, Redman, et.al. (2013) found that public transport service reliability and frequency are two important variables that can attract private motor vehicle users. Other variables such as waiting time, cleanliness and comfort are most valued by users (Dell'Olio, et al., 2011). Study in Phnom Penh found that bus fare and comfort to be the most important aspects for passengers (Choocharukul and Ung, 2011). Japan International Cooperation Agency (JICA, 2011) conducted a research study on practical approach for urban transport planning. They undertook the collection and typological analysis of basic data on current urban situation and traffic patterns of urban agglomerations or cities in the world. Van and Fujii (2011) conducted a study on the attitudes toward car and public transport in six Asian countries (Japan, Thailand, China, Vietnam, Indonesia, and the Philippines). Based on the principle component analysis, they found that there are three factors of attitudes toward car and public transport, i.e. Symbolic affective, Instrumental, and Social orderliness. By comparing the attitudes toward car and public transport among countries they found that there were great divergences across countries in the all three dimensions of attitudes. In another study, Koizumi, et.al. (2013) have analyzed the relationship between urban socio-economic indicators and traffic patterns particularly in the cities of developing countries. They concluded that the metro operation timing is closely related to the achieved level of socio-economic development of cities. The larger the population the more likely they are to develop a metro system, even though GDP per capita is not enough.

Similar to other cities in developing countries, cities in Indonesia have faced the increasing traffic congestion and air pollution. Environmental degradation has continued to occur which is influenced by poor public transport service and increasing dependence on using private vehicle especially motor cycle. Susilo, et.al. (2007) investigated the influences of motorization on the urban residents' travel patterns in the Jakarta Metropolitan Area (JMA). It has been found that motorization is increasing rapidly in Indonesia and especially in the Jakarta metropolitan area (JMA). They found that between 1985 and 2000, there were significant increase in the car ownership, number of trips and travel distance. The lack of good public transport services has caused travelers to shift to private vehicles. The increase of dependency on the use of motor vehicles is much higher in developing countries than in developed countries. Therefore, traffic congestion has increased rapidly and the public transport system is only used by captive users. Muthukannan and Thirumurthy (2008) stated that low accessibility is one of the main reason for people in Chennai, India for not using public transport. Other variables influencing the use of public transport are location of bus stop, fare and waiting time.

Motorization is becoming an issue of concerns for urban governments and citizens in Indonesian cities including in Bali Province. Bali is well known as one of the famous tourist destination in the world. Unfortunately, the cities in Bali Province have not been served well by public transport services. This poor traffic condition has become an important issue that may reduce the attractiveness of Bali. Motor vehicle ownership has increased at the rate of 10 percent per year. On the other hand, the quality of public transport services becomes worse from year to year. Bali consists of 9 region and this study focused on a typical low income region in Bali i.e. Tabanan Region as a case study. One way to measure public transport service quality is by measuring accessibility to reach the city center by public transport. Ryan (2009) stated that walkability influences transit ridership. Exel and Rietveld (2010) identified the importance of public transport travel time. Majority of the previous studies were conducted in large cities with medium to high income condition. None of those studies have classified zonal accessibility level. This study used accessibility concept to analyze accessibility to public transport services for a tipical small and low income region in developing countries. The objective of this study is to investigate the accessibility of residents to public transport services in Tabanan region. The results of the analyses will provide a basis for the government to plan the strategy for improving public transport services.

METHODOLOGY

Bali is one of the famous tourist destination in Indonesia. The Province of Bali has an area of 5,634.40 km2 and population of about 4 million. Tabanan is one of the regency in Bali Province which consists of 11 districts. The area of Tabanan Regency is 839.33 km2 or 14.9% of the area of Bali Province. The population are 441.900 persons with density of 526.49 persons/km2 (Tabanan Bureau of Statistics, 2013). The study area was divided into 11 zones, as shown in Figure 1.

The primary data used in this study are distance and travel time to reach the closest public transport routes. The secondary data were obtained from Tabanan Bureau of Statistic (2013). Microsoft Access was used to compile relevant cross-tabulations and summaries. Tabulations were then converted to Microsoft Excel spreadsheets to allow presentation and modification of format.

Figure-1. Study area zoning system in TabananRegion, Bali-Indonesia

Accessibility to public transport services were measured based on travel distance and travel time. Based on the travel distance and travel time to reach the closest public transport routes, a Z-score is calculated. There is an infinitely large number of normal curve – one for each pair of values for μ and σ. The standard normal distribution is a transformation of the normal distribution. In the standard normal curve, μ = 0 and σ = 1. This standard normal curve can be displayed in terms of Z-scores as indicated in Figure 1. The standard normal curve can be used to simplify the calculation of probabilities for normally distributed populations. Because not all normally distributed random variables have μ = 0 and σ = 1, it is needed to transform the variable so that μ = 0 and σ = 1. It can be done by using the Z-score, which is calculated as follows (Lee, 1993):

$$Z = \underline{X - \mu} \qquad (1)$$

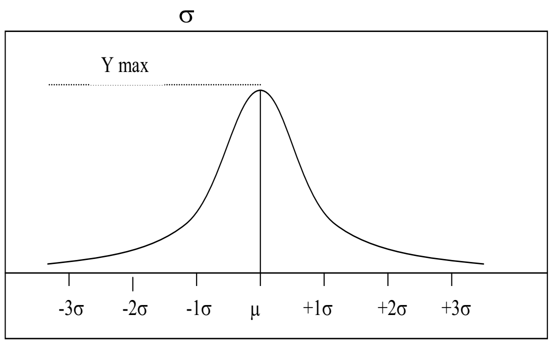

Figure-2. Normal probability distribution with μ = 0 and σ = 0

The zones were grouped into low, medium and high accessibility zones. The zones were then classified further based on percentile values by using formula as follows:

$$Pi = \text{value}\,\frac{i(n+1)}{100} \quad (2)$$

Where:
Pi = percentile -i
i = 1,2,3,.....,99
n = number of zones

To facilitate a visual inspection, a scatter-plot for the Z-score was developed. This Z-score values were plotted in a graph based on the distance and travel time.The Z-score values were then plotted in scatter plot diagram as shown in Figure 3 where the horizontal axis indicates travel time to reach public transport services while the vertical axis indicates distances. Using scatter plot of Z-score, a visual inspection can be done to identify outliers and clusters of zones. From the four quadrants in Figure 3, the upper right quadrant (quadrant D) indicates the cluster of zones with high accessibility values based both on distances and travel time. Zones in the lower left quadrant (A) are zones with low accessibility values for both distances and travel time. The upper left quadrant (B) indicates a cluster of zones with a low travel time but have relatively short discances to reach public transport routes. The lower right quadrant (C) is for zones that have a high accessibility values based on travel time but low accessibility values based on distances.

Table-1. Public transport routes in Tabanan

No	Public transport route	No of fleets (unit)	Length of route (km)
1	Kediri-Tabanan-Pesiapan	56	5
2	Tuakilang-Tabanan-Pesiapan	21	5
3	Kediri-Tabanan-Tuakilang	61	7
4	Tabanan-Kukuh-Marga	3	9
5	Kediri-Tanah lot	4	11
6	Tabanan-Buahan-Marga	2	12
7	Pesiapan-Tabanan-Bongan	13	6
8	Kabakaba-Kediri-Tabanan	3	9
9	Pesiapan-Tabanan-Yehganga	5	6
10	Tabanan-Kediri-Taman Ayun	-	-

Source: Tabanan Department of Transport, 2014

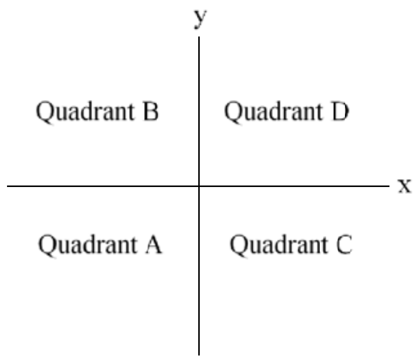

Figure-3. Z-score diagram of accessibility to public transport services

RESULTS

Public transport routes

Table 1 shows public transport routes in Tabanan Region. There are 10 routes available to serve movement of people. The number of fleets varies from 3 units to 56 units per route. The length of the routes varies from 5 to 12 km.

Travel time to reach the closest public transport routes

Travel time analyses include walking travel time to the closest public transport route and passenger's waiting time from each zone. Based on the survey, it was found that the average walking speed was 71.76 m/minute. Table 2 shows walking distance and walking travel time required to reach the closest public transport route. The walking distances vary from 0.17 to 4.6 km with the average walking distance was 1.84 km. Walking travel times were varies between 2.42 to 64.71 minutes. The shortest walking travel time was experienced by zone 5 (Delod Peken) i.e. 2.42 minutes while the longest was experienced by zone 10 (Tunjuk) i.e. 64.71 minutes. With the assumption of ideal walking distance of 500 m, Table 3 presents the values of walking accessibility. It can be seen that 45.46% of zones were in high accessibility category, 9.09% were in medium accessibility and 45.46% were in low accessibility category.

Table-2. Walking distance and travel time to reach the closest public transport routes

Zone No	Zone/ district	Walking distance (km)	Walking travel time (minutes)
1	Sudimara	3.93	56.14
2	Bongan	0.36	5.14
3	Gubug	0.23	3.28
4	DauhPeken	0.53	7.57
5	DelodPeken	0.17	2.42
6	DajanPeken	0.48	6.85
7	Subamia	2.65	37.85
8	Denbates	0.29	4.14
9	Buahan	4.3	61.42
10	Tunjuk	4.6	65.71
11	Wanesari	2.7	38.57

DOI: 10.1051/matecconf/20165802002

Table-3. Walking accessibility to reach closest public transport routes

Walking comfort level (meter)	Zone number	Percentage (%)
0 -500 (high)	5	45.46
500 - 1000 (medium)	1	9.09
>1000 (low)	5	45.46

Passenger's waiting time

Passenger's waiting time is total time required by passenger to wait public transport arrival. Table 4 shows that the passenger's waiting time varies from 0.96 to 4.7 minutes.

Table-4. Passenger's waiting time

Zone no	Zone/district	Passenger's waiting time (minutes)
1	Sudimara	4.709
2	Bongan	4.250
3	Gubug	4.709
4	DauhPeken	0.966
5	DelodPeken	0.961
6	DajanPeken	0.964
7	Subamia	1.383
8	Denbates	1.429
9	Buahan	1.063
10	Tunjuk	1.429
11	Wanesari	1.429

Total Passenger's Travel Time to Reach the Closest Public Transport Routes

Total passenger's travel time to reach the closest public transport route consists of walking time and waiting time. Table 5 presents total passenger's walking travel time to reach the closest public transport routes from each zone in Tabanan Regency. The longest travel time was experienced by zone 10 (Tunjuk) i.e. 67.14 minutes with a distance to be traveled of 4.6 km. On the other hand, the shortest travel time was experienced by zone 5 (DelodPeken) i.e. 3.39 minutes with distance of 0.17 km. The average walking travel time to reach the closest public transport routes was 28.40 minutes.

Table-5. Total walking travel time to reach the closest public transport routes

Zone no	Zone/district	Distance (km)	Total walking travel time (minutes)
1	Sudimara	3.9	60.85
2	Bongan	0.4	9.39
3	Gubug	0.23	7.99
4	DauhPeken	0.53	8.53
5	DelodPeken	0.17	3.39
6	DajanPeken	0.48	7.82
7	Subamia	2.6	39.24
8	Denbates	0.29	5.57
9	Buahan	4.3	62.49
10	Tunjuk	4.6	67.14
11	Wanesari	2.7	40.00

Accessibility classification based on traveltime to the closest public transport routes

Table 6 and Figure 4 show accessibility classification based on travel time to reach the closest public transport routes in Tabanan Regency. It can be seen that three zones (Zone 5, 6, 8) were in high accessibility category, three zones were in medium category (2, 3, 4), three zones in low category (1, 7, 11), and two zones in very low category (9, 10).

Table-6. Accessibility classification based on total travel time to reach the closest public transport routes

Zone no	Zone/district	Walking travel time (minutes)	Accessibility classification
5	DelodPeken	3.39	High
8	Denbates	5.57	High
6	DajanPeken	7.82	High
3	Gubug	7.99	Medium
4	DauhPeken	8.53	Medium
2	Bongan	9.39	Medium
7	Subamia	39.24	Low
11	Wanesari	40.00	Low
1	Sudimara	60.58	Low
9	Buahan	62.49	Very low
10	Tunjuk	67.14	Very low

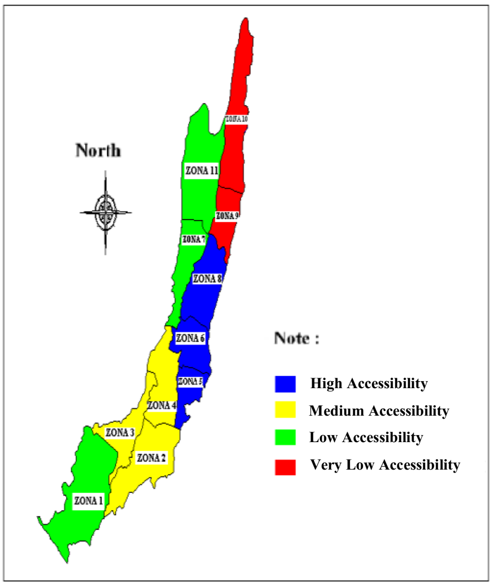

Figure-4. Map of accessibility classification based on walking travel time to reach the closest public transport routes

Accessibility Based on Travel Distance

Table 7 and Figure 5 show accessibility classification based on travel distance to reach the closest public transport routes in Tabanan Regency. Three zones were in high accessibility category (zone 3, 5, 8), three zones were in medium category (zone 2, 4, 6), three zones in low category (zone 1, 7, 11) and two zones in very low category (zone 9, 10).

Table-7. Accessibility classification based on travel distance to the closest public transport routes

Zone no	Zone/district	Walking travel time (minutes)	Accessibility classification
5	DelodPeken	0.17	High
3	Gubug	0.23	High
8	Denbates	0.29	High
2	Bongan	0.4	Medium
6	DajanPeken	0.48	Medium
4	DauhPeken	0.53	Medium
7	Subamia	2.6	Low
11	Wanesari	2.7	Low
1	Sudimara	3.9	Low
9	Buahan	4.3	Very Low
10	Tunjuk	4.6	Very Low

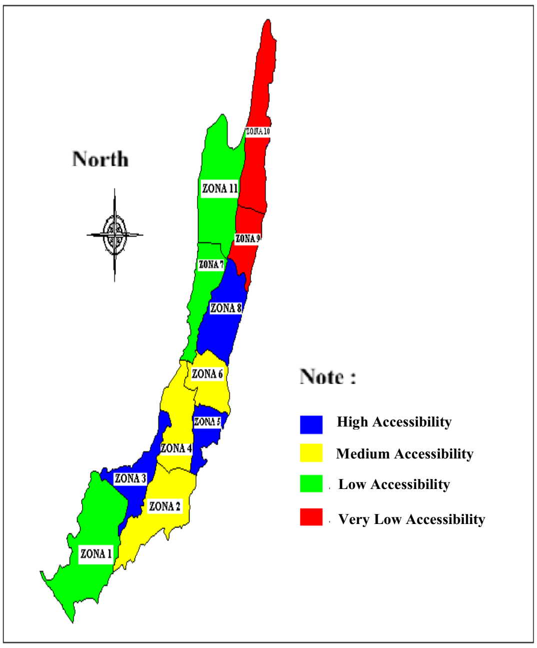

Figure-5. Map of accessibility classification based on travel distance to the closest public transport routes

Z-Score Diagram

Z-Score diagram is used to show the position of each zone in terms of its accessibility. Horisontal axis (Zx) represents Z-score for accessibility based on walking travel time, while vertical axis (Zy) indicates Z-score for accessibility based on travel distance to the closest public transport routes. Z-score positif indicates that the accessibility of the zone above the average standard deviation for all zones while Z-score negative indicates the accessibility below the average standard deviation. Table 8 shows the Z-score for all zones and Figure 6 shows position of each zone in the Z-Score diagram.

Table-8. Z-score for accessibility to public transport services

Zone No	Zone/ district	(Zx) Z-score Time	(Zy) Z-score Distance	Position in Z-score diagram
1	Sudimara	1.252	1.150	D
2	Bongan	-0.733	-0.794	A
3	Gubug	-0.788	-0.888	A
4	DauhPeken	-0.767	-0.722	A
5	DelodPeken	-0.965	-0.922	A
6	DajanPeken	-0.794	-0.750	A
7	Subamia	0.418	0.427	D
8	Denbates	-0.881	-0.855	A
9	Buahan	1.316	1.372	D
10	Tunjuk	1.495	1.538	D
11	Wanesari	0.447	0.483	D

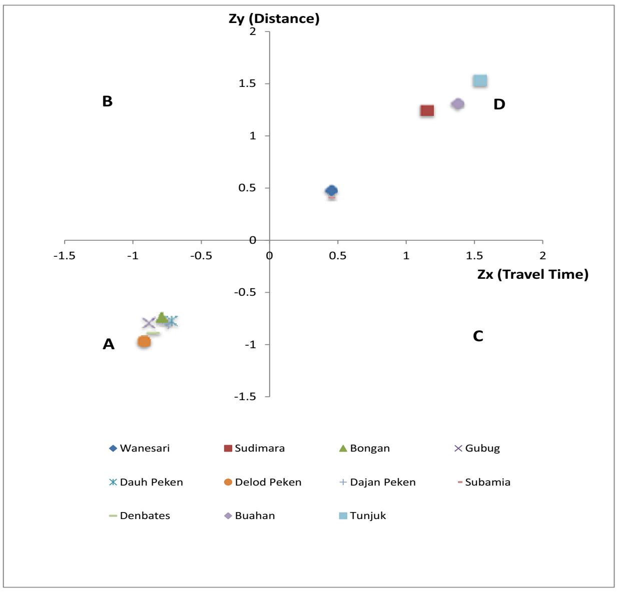

Figure-6. Z-score diagram for accessibility to public transport services

DISCUSSIONS

Quadrant A indicates zones with negative Z-score values for both travel time and distance (the value below the average standard deviation for all zones). Quadrant D indicates zones with Z-score values for both travel time and distance were positive (the value above the average standard deviation for all zones). Table 9 shows that there were 6 zones in quadrant A including Bongan, Gubug, Dauh Peken, Delod Peken, Dajan Peken and Denbates. Table 10 shows that there were 5 zones in quadrant D, i.e. Sudimara, Subamia, Buahan, Tunjuk, and Wanesari. Public transport users tend to be higher in those zones with high accessibility values. This agrees with the previous studies which stated that accessibility is an important factor to influence people to use public transport. Based on these results, those zones that have negative Z-score values need attention in re-structuring public transport network in the future in order to increase their accessibility values.

Table-9. Zones in quadrant A

Zone No.	Zone/ district	Zx (Z-score time)	Zy (Z-score distance)
1	Bongan	-0,733	-0,794
2	Gubug	-0,788	-0,888
3	Dauh Peken	-0,767	-0,722
4	Delod Peken	-0,965	-0,922
5	Dajan Peken	-0,794	-0,75
6	Denbates	-0,881	-0,855

Table-10. Zones in quadrant D

Zone No.	Zone/ district	Zx (Z-score time)	Zy (Z-score distance)
1	Sudimara	1,252	1,15
2	Subamia	0,418	0,427
3	Buahan	1,316	1,372
4	Tunjuk	1,495	1,538
5	Wanesari	0,447	0,483

CONCLUSIONS

Accessibility to public transport services in Tabanan Region was analyzed based on travel distance and travel time to reach the closest public transport routes. Based on Z-score, it was found that six zones were in quadrant A which means that these zones were in low accessibility category (Bongan, Gubug, Dauh Peken, Delod Peken, Dajan Peken and Denbatas). On the other hand five zones were identified in quadrant D. These zones (Sudimara, Subamia, Buahan, Tunjuk and Wanasari) have a high accessibility values to reach public transport routes. Therefore, improvement of infrastructures and public transport services need to be given priority in those six zones with a low level of accessibility values. The actions required include: developing new public transport routes network to serve people living in low accessibility zones; improving the quality of public transport services; increasing the number of public transport fleets in order to reduce headway; provide subsidy to the public transport user in order to reduce fare and attract people to use public transport.

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