PUBLIC TRANSPORT PLANNING METHOD FOR BANDUNG (INDONESIA)

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Abstract: Urban congestion is always occurred in almost large cities in Indonesia for instance Bandung. Public transport is usually being suspected as one of the congestion's trouble maker in Indonesia. This is may due to delay and congestion occured resulting from overlapped routes, under-supply number of vehicles etc which causes low level of service, low journey speed, high travel time etc.

This paper will explain in a great detail a method of public transport planning by combining an '**optimisation**' technique with a '**superimpose**' technique to obtain some best planned routes which will increase the efficiency and the level of service of public transport. The method has been applied in Bandung (Indonesia) and some results will be explained in a great detail. General conclusion regarding the advantageous and the applicability of the approach to other environments will also be included.

1. INTRODUCTION

The objective of this study is:

- to develop a public transport route planning model which relates the importance of all related aspects such as: land-use pattern, transportation network, population density pattern, travel demand pattern, operation system and level of service as well as the government's policy. It is expected that the developed model can obtain such best optimum routes which will increase the efficiency, the level of service of public transport and profitable to all related agencies (government, users, operators).

- It is expected that the developed model can be used for all other similar types of urbanised area or cities in Indonesia.

2. METHODOLOGY

The scope of the analysis will be restricted only for factors which directly related to the pattern of movement and route services and also some variables which are required in computer process using MOTORS package program (**Steer, Davies and Gleave, 1984** and **Tamin, 1995abc**). Furthermore, the analysis will only be concentrated in explaining the demand side such as: transport movement and landuse pattern as well as population density pattern (**Morlok, 1988; Manheim, 1979**).

However, from the supply side, it covers the determination of existing public transport services condition and route characteristics and also the road network characteristics in the study area. The general framework of the study is shown in **Figure 1** which showing the process carried out throughout the study **(Tamin, 1995abc; Manheim, 1979; Morlok, 1988)**.

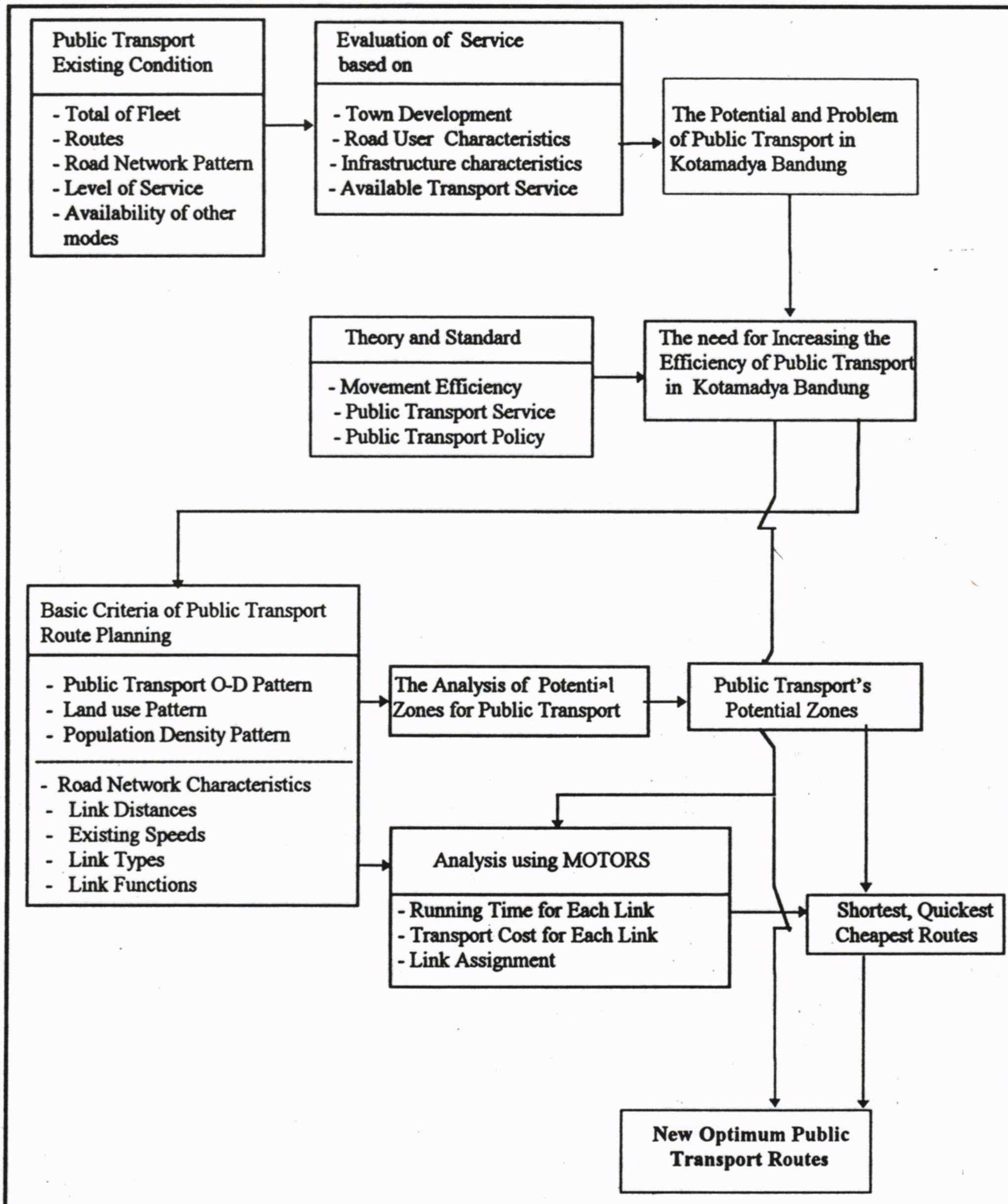

FIGURE 1: General Framework of Public Transport Network Study: A Case Study in Bandung (Source: **Tamin, 1995abc)**

3. THE CHARACTERISTIC OF KOTAMADYA BANDUNG

3.1 Demographic Characteristic

In transport planning point of view, population is the major subject who can generate the traffic and vehicle movement, in the sense, that the areas with highest density population will become the highest potential movement generators (**Blund and Black, 1984; Cresswell, 1979; Manheim, 1979; Morlok, 1988**). The total population of Kotamadya Bandung in 1992 is 1,816,041 inhabitants increasing with the growth rate of 0.26% per annum between 1988-1992.

The density of population in Kotamadya Bandung is 11,059 people/km2 in Kecamatan Bojongloa Kaler, Astana Anyar, Batununggal dan Cibeunying Kidul. The highest density kecamatan is usually located near the city center dominated by dense housing areas. The total population and density pattern will obviously affect the pattern of movement in this study area (**Manheim, 1979; Cresswell, 1979**).

3.2 Land-Use Pattern

The condition of land-use in Bandung in 1990 is dominated by housing activities (52.49%), open space (31.47%) and others as: industry, trade, office and social and empty spaces. The spreadness of land use activities in Bandung shows that most of the areas are having mixed activities such as: housing, commercial and trade as shown in **Table 1** (see **Tamin, 1995abc**).

TABLE 1: Land Use in Kotamadya Bandung (1990)

No	Activity	Area (Ha)	(%)
1	Housing	8.793,06	52,49
2	Office & Social	553,04	3,31
3	Trade	458,85	2,74
4	Industry	610,73	3,65
5	Military Area	348,52	2,08
6	Open Space	5.270,47	31,47
7	Others	841,08	5,02
	Total	16.749,61	100

Source: RIK 2005 Kotamadya Bandung

4. EXISTING OPERATION AND SERVICES CONDITION

From the result of public transport survey carried out in this study (**Tamin, 1995abc**), as shown in **Table 2**, the existing condition of public transport services and operation are as follows:

TABLE 2: Operation System and Service of Public Transport in Kotamadya Bandung

No	Operation System and Public Transport Services	Conditions
1	Public Transport Routes	- Overlapped Routes: mostly 3-8 routes - Route Pattern: 29 routes (54.6%) serving CBD area
2	Service Area	- 0-2 kms from CBD: the coverage area is 0.2-0.5 km (90% of the area) - 2-4 kms from CBD: the coverage area is 0.5-1 km (75% of the area)
3	Journey Speed and Journey Time	- The speed of angkots ranges between 9.7-27.8 km/hr with average of 16.1 km/hr - The speed of buses ranges between 11.7-26.5 km/hr with average of 18.5 km/hr
4	Occupancy and Loading Factor	- Average occupancy: Bus (43 people/veh), Medium Bus (23 people/veh), Angkot (8 people/veh) - Average Loading Factor: Bus (71%), Medium Bus (97%), Angkot (70%)
5	Frequency and Headway	- Average frequency: Bus (1-11 vehs/hr/direction), Angkot (6-148 vehs/hr/direction) - Average Headway: Bus (2.4-360 mins/veh/direction), Angkot (0.4-8.7 mins/veh/direction)

Source: Survey and Analysis Results

5. NEW ROUTE PLANNING

5.1 Basic Criteria

The new public transport route is heavily affected by the landuse characteristics along the corridor passed by the public transport (**Gray and Lester, 1979; Blund and Black, 1984**). The best planned route is the route which enables someone increase his accesibility from his origin to destination. Some factors that can be used for consideration in planning the new routes are as follows (**Gray and Lester, 1979**):

a. Land Use Pattern

It is hoped that the public transport can serve good accesibility to everyone who choose the public transport. To fulfill that, the route corridor should pass along the high density populated land uses and the high attracted places (**Gray and Lester, 1979**).

b. Public Transport Demand Pattern

The pattern of public transport movement in certain area can represent the pattern of optimum corridor (**Manheim, 1979**). The best planned routes should follow this pattern to make the movement more efficient. The public transport route should also be planned to be consistent with the pattern of existing movement so that the number of transfer between modes could be minimised (**Cresswell, 1979**). **Figure 2** shows the existing public transport demand movement within Kotamadya Bandung.

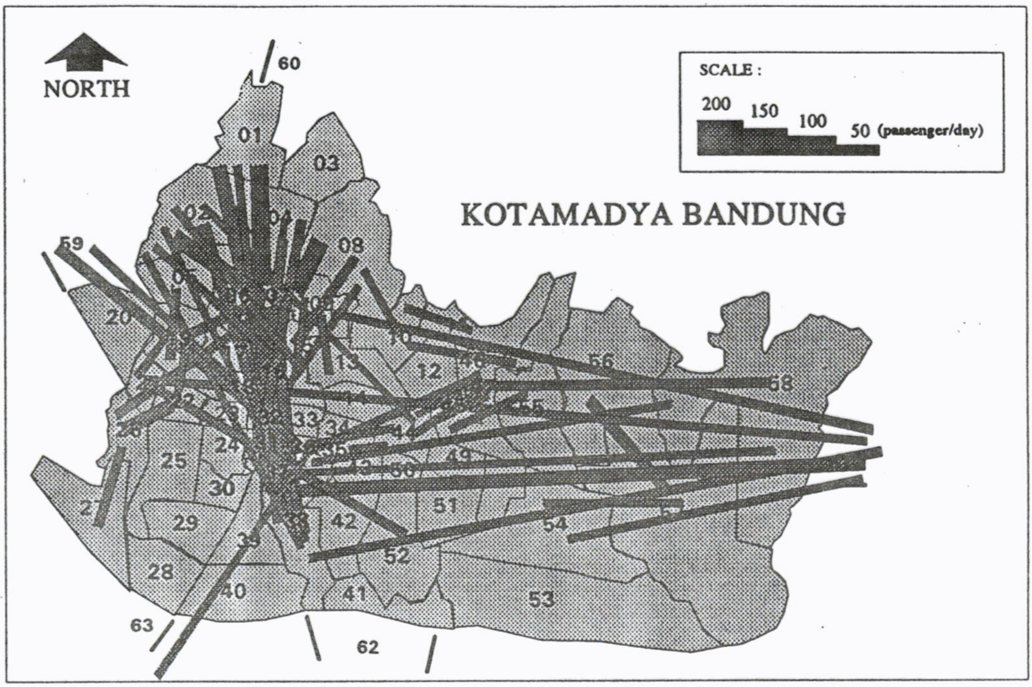

FIGURE 2:The Existing Public Transport Demand Movement

c. Population Density

One priority factor in public transport services is to serve the high density populated area. This type of area in general will have high potential demand for trip generators and attractors (**Black, 1981**). The best routes should be planned as close as possible to this area and cover this high potential demand area (**Gray and Lester, 1979**).

d. Service Area

Public transport is one type of transport mode which will serve the public needs. Therefore, the public transport services are expected to cover every inches of Kotamadya Bandung area so that every citizen wherever they are will have the same accessibility and mobility in Kotamadya Bandung (**Cresswell, 1979**).

e. Road Network Characteristic

The existing condition of road network characteristics will obviously shape the service pattern of the available public transport routes (**Blund and Black, 1984**). They are as follows: configuration, classification and function, road width, type of operation. The public transport operation is obviously influenced by the existing road network characteristics as shown in **Figure 3**.

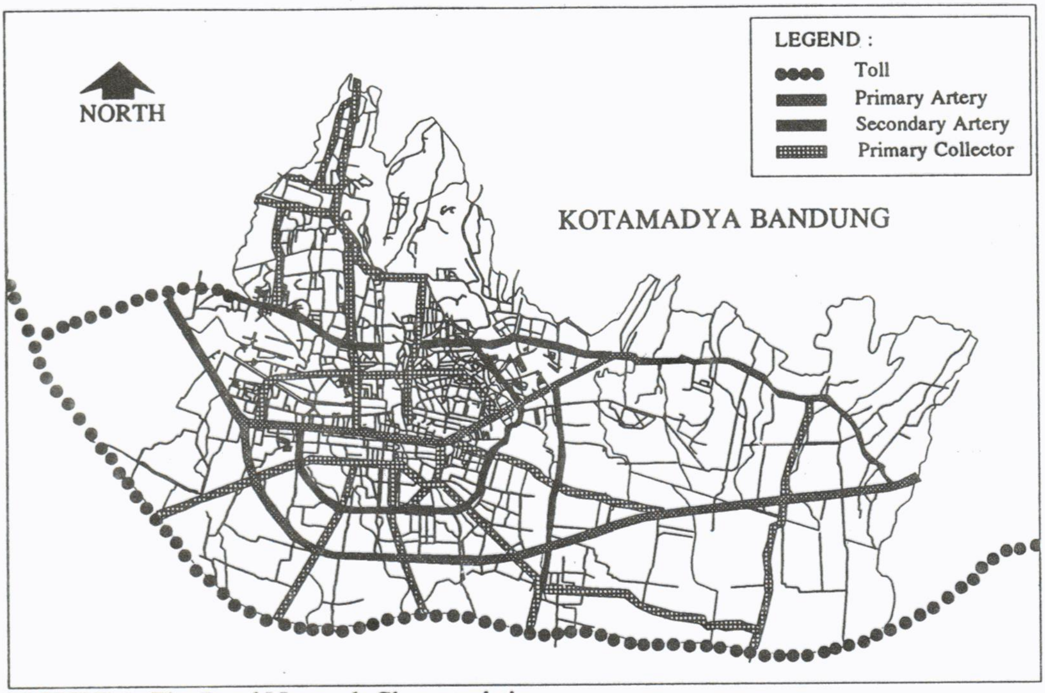

FIGURE 3: The Road Network Characteristics

5.2 Public Transport Service Area

a. Service Zone Criteria

The following zones require some public transport services (**Cresswell, 1979**). They are as follows:

- Primary centers;
- High density populated area (housing);
- Office, industrial, education, and shopping centers.

b. Potential Zone Analysis

- From the analysis of public transport origin-destination survey (**Tamin, 1995abc**), it can be identified some O-D pairs which having high potential demand. These potential O-D pairs will be considered in determining the potential routes. Other than these potential O-D pairs, it can also be identified the zone locations of high trip generators and attractors for public transport demand. These potential zones are becoming the major priority in deciding the starting and ending points of the planned corridors.

- The high density populated areas are the major potential areas to be covered by the public transport services for instance: the CBD area of the Kotamadya Bandung, in general located near the city center, having the highest density populated area **(Gray**

and Lester, 1979). However, in the near future, it is predicted that the housing area will shift from the city center to the suburban area.

- Based on the landuse map (**see Figure 4**) of Kotamadya Bandung, it can be shown that the housing areas are dominating the whole area and well distributed throughout the Kotamadya Bandung (52.49%). Therefore, it can be determined that, if possible, the public transport routes should cover the whole area of the Kotamadya Bandung (**Tamin, 1995abc**).

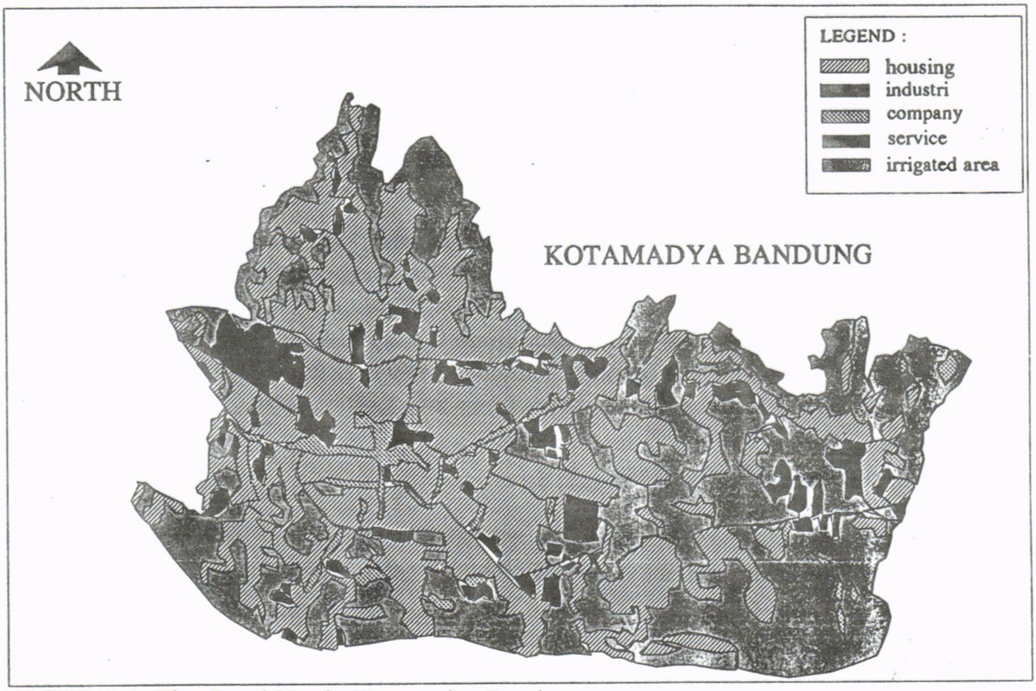

FIGURE 4: The Land Use in Kotamadya Bandung

- One of the most attracted locations for the citizens of Kotamadya Bandung to fulfill their daily needs is the commercial and shopping centers (**Blund and Black, 1984**). In Kotamadya Bandung, the locations of such activities is located mostly in the city centers (**Tamin, 1991,1992; Morlok, 1988**). These most attracted locations area becoming the major priority location to be considered in choosing the best planned for public transport routes.

5.3 The Route Analysis Using MOTORS

In planning the new routes, some simulation processes to be followed, in general, are as follows:

- creating the shortest, quickest and cheapest routes (using P10, P20, P40 Modules).

- superimposing each route by land use, movement pattern, population density pattern, service area, and road network to consider the type of route pattern.

- deciding the service pattern along each route (shortest, quickest and cheapest routes), by taking into account the service zones closest to the route pattern obtained by MOTORS.

- The evaluation of public transport performance (Modules: P10, P20, P40, P50, M20, P80 and routes obtained from superimpose analysis). The types of routes being analysis covers:
  - Existing route
  - Shortest route (planned)
  - Quickest route (planned)
  - Cheapest Route(planned)

- The best planned routes were then chosen using the Multi-criteria Analysis.

5.4 Multi-Criteria Analysis Method

Factors affecting the route performance is factors which are directly related to the public transport and obtained from the results of MOTORS simulation and superimpose processes. The best planned route is routes which satisfy the needs of users, operators and government. In choosing the best routes, some factors affecting the users, operators and government will be taken into account. These factors will then be evaluated using the Multi-Criteria analysis (**Blund and Black, 1984, Gray and Lester, 1979, Tamin, 1995abc**).

a. Performance Evaluation

Some performance parameters which obviously directly related to the public transport operation will be taken into account (**Gray and Lester, 1979; Blund and Black, 1984**). They are as follows:

- **Distance:** the route distance is becoming one of the major advantageous factor for the users in choosing the public transport mode. The shortest distance which is line up with the movement pattern is becoming the best route for people who decide to use public transport for their modes of transportation. The existing route distance is built based on the shortest, quickest and cheapest route pattern which have been superimposed using other criteria (**Manheim, 1979; Morlok, 1988**).

- **Journey Time**: is also becoming the major factor in making the public transport more attractive such as: short journey time. The journey time criteria used for the evaluation is one of the characteristic representing the real situation obtained from MOTORS simulation process.

- **Volume Capacity Ratio**: the V/C ratio shows the traffic density of links passed along by the public transport routes. Routes which having low V/C ratios show relatively better routes. The values of the V/C ratios are obtained as output of MOTORS simulation process.

- **Overlapping**: The most desirable corridors are corridors which having small number of overlapped public transport routes.

b. Weighting Criteria

The evaluation of selected factors is carried out using performance parameter which is defined as by giving the relative weighting for each performance parameter (see **Table 3**). The weighting values of each performance parameter are as follows (**Tamin, 1989; Tamin, 1995abc**):

TABLE 3: The Weight of Performance Parameter

No	Route Distance (Km)	Journey Time (Minute)	V/C	Overlaped Routes	Weight
1	≤ 7.9	≤ 15.9	<0.40	< 2	5
2	8 - 12.9	16 - 20.9	0.40 - 0.55	2.1 - 3	4
3	13 - 17.9	21 - 25.9	0.56 - 0.70	3.1 - 4	3
4	18 - 22.9	26 - 30.9	0.71 - 0.85	4.1 - 5	2
5	> 22.9	> 30.9	> 0.85	> 5	1

Source: Analysis Results

c. State-Preference Approach

In order to have some knowledge from the users, operators and government points of view in evaluating the weights of each selected performance parameter, a public transport survey was carried out (**Cresswell, 1979; Gray and Lester, 1979**). The purpose of the survey is to obtain the preference of users, operators and government in evaluating the selected performance parameter.

Students, workers, shoppers, etc. are chosen as representing the users, the owners and drivers as operators and BAPPEDA, DLLAJ, ORGANDA, DTK are chosen as government. Having evaluated the result obtained from the respondent, some performance preference weights for users, operators and govenrment are given in **Tables 4-7 (Tamin, 1995abc)**.

TABLE 4: 'Preference Weight' for Route Distance

No	Route Distance (Km)	Preference Weight (User)	Preference Weight (Operator)	Preference Weight (Government)
1	≤ 7.9	0.59	0.16	0.42
2	8 - 12.9	0.17	0.21	0.52
3	13 - 17.9	0.14	0.16	0.06
4	18 - 22.9	0.02	0.28	0.00
5	> 22.9	0.08	0.21	0.00

Source: Analysis Results

TABLE 5: 'Preference Weight' for Journey Time

No	Journey Time (Minutes)	Preference Weight (User)	Preference Weight (Operator)	Preference Weight (Government)
1	≤ 15.9	0.49	0.12	0.61
2	16 - 20.9	0.29	0.00	0.26
3	21 - 25.9	0.09	0.12	0.00
4	26 - 30.9	0.08	0.33	0.13
5	> 30.9	0.05	0.44	0.00

Source: Analysis Results

TABLE 6: 'Preference Weight' for Volume/Capacity (V/C)

No	V/C	Preference Weight (User)	Preference Weight (Operator)	Preference Weight (Government)
1	<0.40	0.10	0.12	0.03
2	0.40 - 0.55	0.62	0.56	0.94
3	0.56 - 0.70	0.28	0.30	0.03
4	0.71 - 0.85	0.00	0.02	0.00
5	> 0.85	0.00	0.00	0.00

Source: Analysis Results

TABLE 7: 'Preference Weight' for Overlapped Routes

No	Overlapping Routes	Preference Weight (User)	Preference Weight (Operator)	Preference Weight (Government)
1	< 2	0.16	0.79	0.42
2	2.1 - 3	0.66	0.16	0.52
3	3.1 - 4	0.11	0.02	0.06
4	4.1 - 5	0.03	0.02	0.00
5	> 5	0.03	0.00	0.00

Source: Analysis Results

5.5 The Best Planned Routes

The following stage is to obtain the best planned routes based on the selected performance previously defined (**Tamin, 1995abc**). The best route is chosen among the selected routes which having the best performance, in the sense, that the best routes are having the largest total number of weights.

- **The Best Route Analysis**

  In planning the new public transport routes, it is assumed that the total number of existing routes is remain the same and having similar condition with their existing condition (**Tamin, 1995abc; Gray and Lester, 1979**). If it is found more than one best routes (in the sense that more than one route having equal and largest weights), then, the second stage process should be carried out. In this case, the performance parameter should be considered are as follows (**Cresswell, 1979; Bruton, 1985; ITE, 1982**):

a. Corridor which has lowest journey time will be chosen.
b. Corridor which has shortest distance will be chosen
c. Corridor which has lowest V/C ratio will be chosen
d. Corridor which has smallest number of overlapped routes will be chosen.

Having carried out the second stage process, the final result is given in **Table 8**.

TABLE 8: Best Routes Based on User, Operator and Government Preference (**Tamin, 1995abc**)

Scenario	User's Preference		Operators's Preference		Government's Preference	
	Total	(%)	Total	(%)	Total	(%)
1. Existing Route	9	17.0	14	26.4	7	13.3
2. Shortest Route	15	28.3	16	30.2	16	30.1
3. Quickest Route	14	26.4	15	26.4	21	39.6
4. Cheapest Route	15	28.3	8	15.0	9	17.0
TOTAL	53	100	53	100	53	100

Source: Analysis Results

It can be seen that using User-Preference, it is found that only 9 routes (17%) of the chosen routes are the same as the existing routes and 44 routes (83%) were obtained through optimisation process.

However, using Operator-Preference, it is found that only 14 routes (26.4%) of the chosen routes are the same as the existimg routes and 39 routes (73.6%) were obtained through optimisation process. Finally, for the Government-Preference, the existing routes are 7 routes (13.3%) and the rest (46 routes) around 86.7% were obtained through optimisation process (see **Tamin, 1995c**).

Figures 5-9 show the bus routes chosen based on user's, operator's and government's choice for Sadang Serang-Caringin Line (32), Dago-Riung Bandung Line (18), Dipati Ukur-Panghegar Line (20), Ciwastra-Cijerah Line (29) and Cicadas-Elang Line (34). It can be seen from the figures that most of the best routes using the Multi-Criteria technique with State-Preference approach are almost different with the existing routes.

It can be seen from **Figure 5** for Sadang Serang-Caringin Line (32), all the routes chosen based on user's, operator's and government's preference are totally different with the existing route. This route connects Sadang Serang as one of the highest density of residential area in Bandung with Caringin as one of the largest shopping area in Bandung.

All the three chosen routes are passing the southern part of the Bandung CBD's area and crossing mostly the office, residential and shopping areas. The existing route is passing the northern part of Bandung which is longer in term of distance and, hence, journey time.

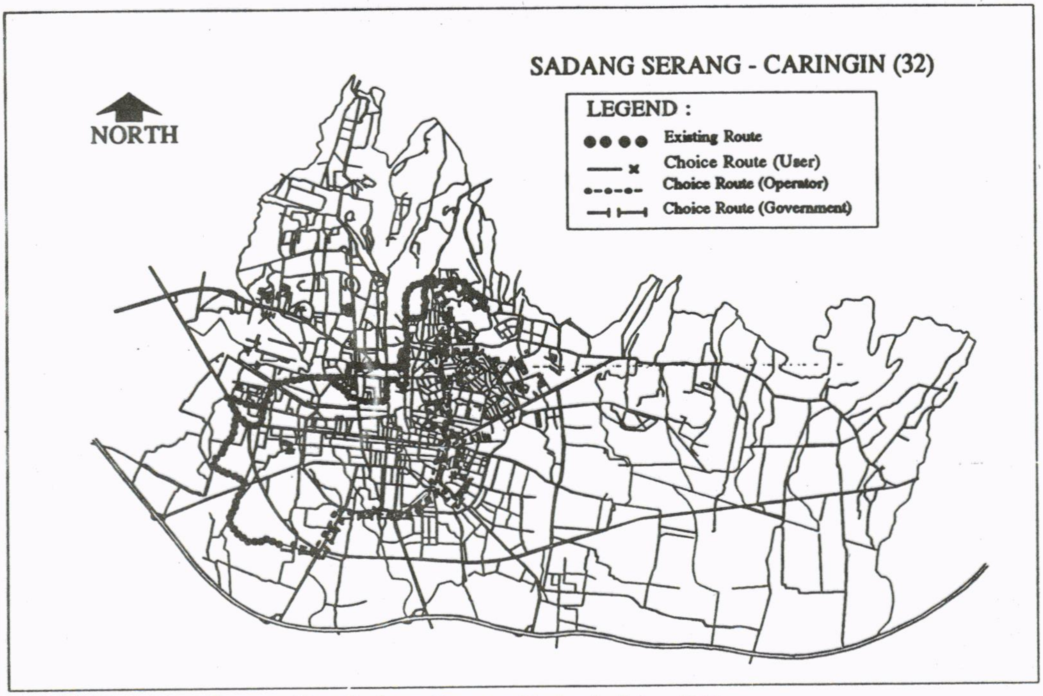

FIGURE 5: Best Routes For Sadang Serang-Caringin Line (32)

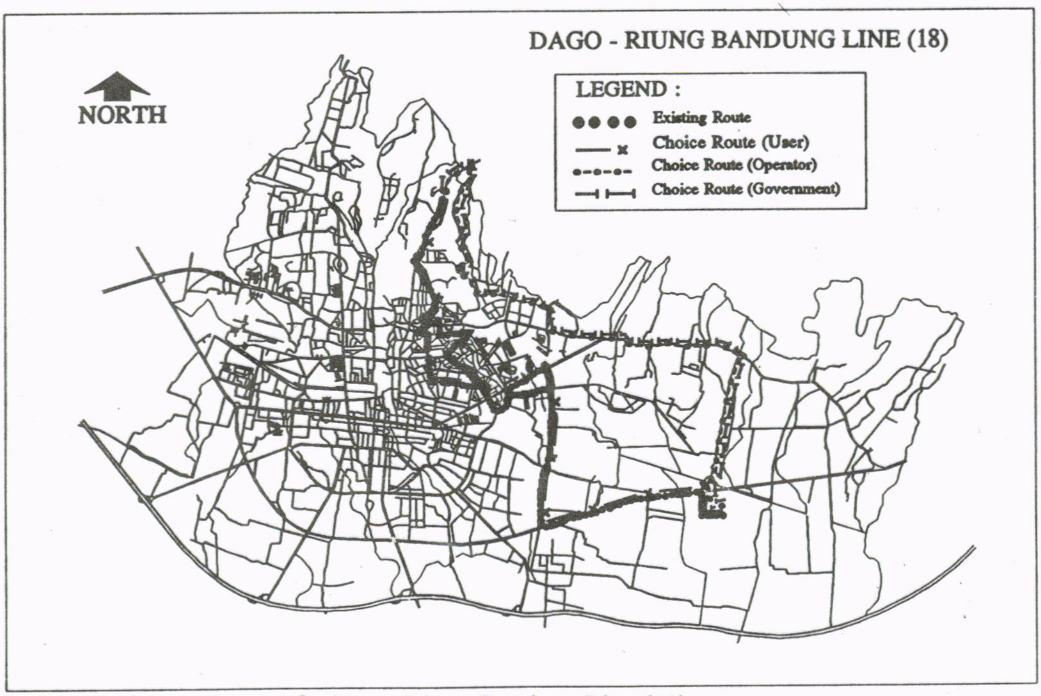

FIGURE 6: Best Routes for Dago-Riung Bandung Line (18)

It can be seen from **Figure 6** for Dago-Riung Bandung Line (18), the route chosen based on user's preference is not different with the existing route except the routes chosen based on operator's and goverment's preference. This route connects Dago as one of the highest density of residential area in the southern part of Bandung with Riung as one of the newest and largest residential area in Southeast Bandung. Other than residential area, Dago area has two major and largest universities (Institute of Technology Bandung and University of Padjadjaran).

The existing route and the route chosen by the user's preference are passing the central part of Bandung area and quicker in term of journey time since the routes pass Soekarno-Hatta road which is an primary arterial road for Bandung. The other two chosen routes crossing the northern part of the Bandung and passing the secondary arterial road which is fairly congested and hence high journey time. However, since most of the residential areas are along this road, the operaters give more preference to this route rather than the existing route. Futhermore, since it is not crossing the central area and hence increasing traffic congestion in central area, the government gives preference to this route.

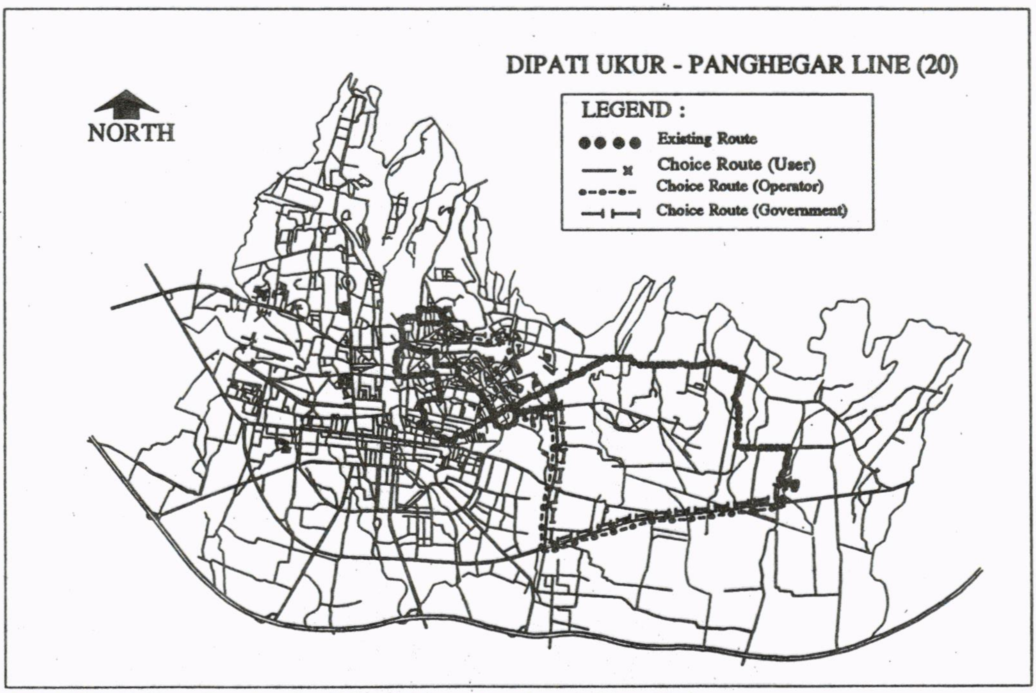

FIGURE 7: Best Routes for Dipati Ukur-Panghegar Line (20)

It can be seen from **Figure 7** for Dipati Ukur-Panghegar Line (20), the three routes chosen based on user's, operator's and government's preference are different with the existing route. This route connects Dipati Ukur (University of Padjadjaran) in the southern part of Bandung with Panghegar as one of the newest and largest residential area in Southeast Bandung.

The existing routes are crossing the northern part of Bandung area and passing the secondary arterial road which is fairly congested and hence high journey time. The three chosen routes are quicker in term of journey time since the routes pass Soekarno-Hatta road which is an primary arterial road for Bandung.

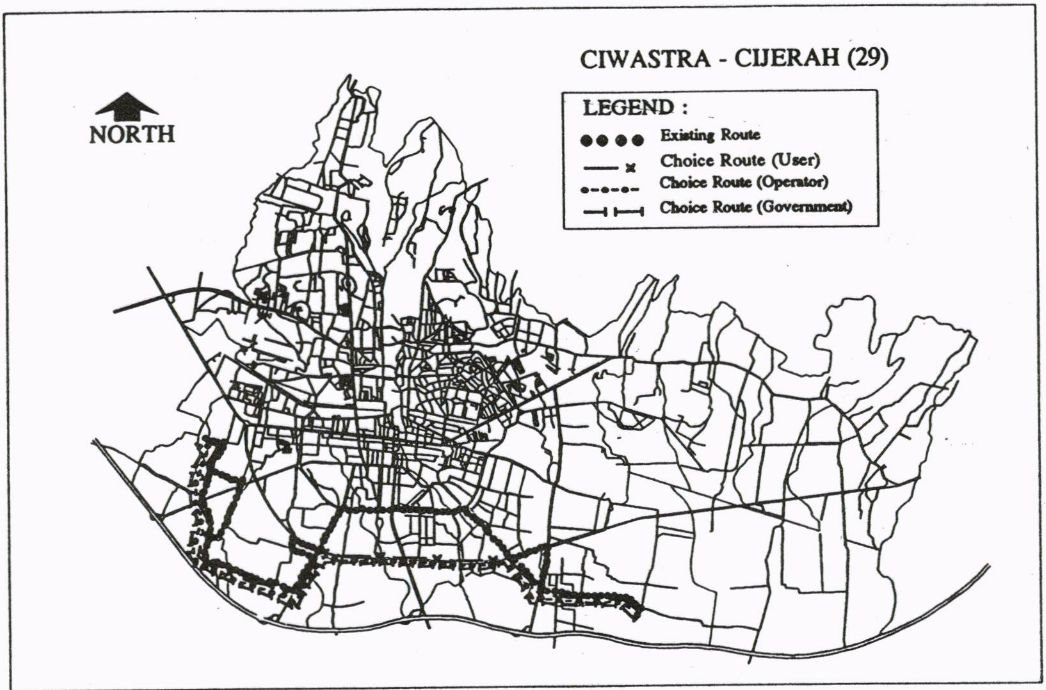

FIGURE 8: Best Routes for Ciwastra-Cijerah Line (29)

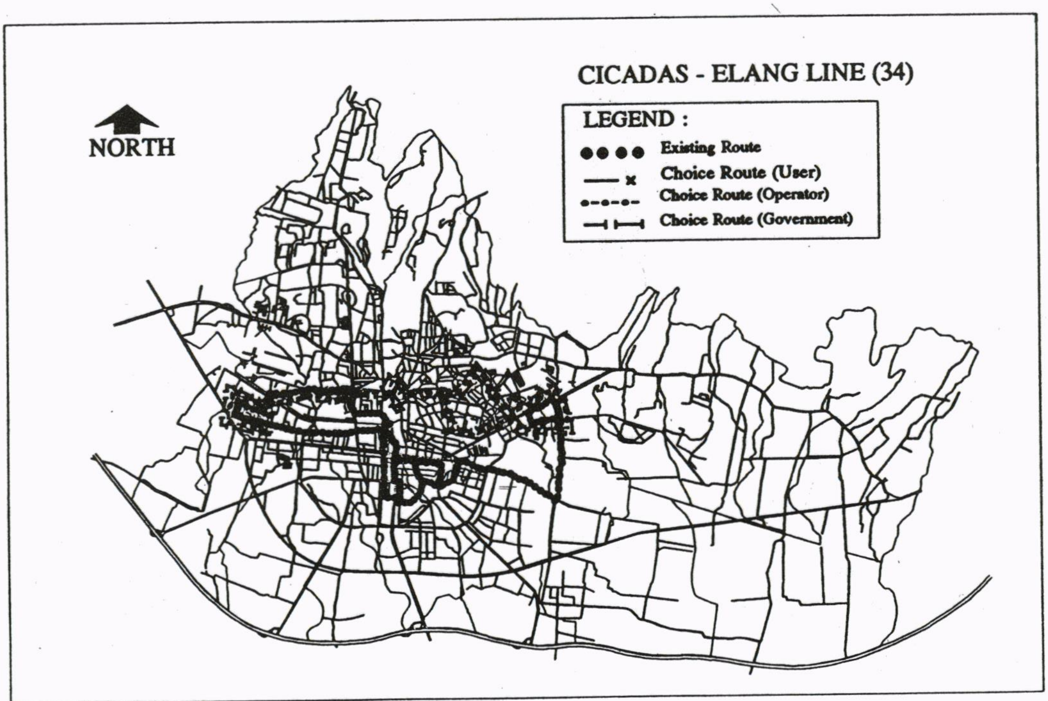

FIGURE 9: Best Routes for Cicadas-Elang Line (34)

It can be seen from **Figure 8** for Ciwastra-Cijerah Line (29), the three routes chosen based on user's, operator's and government's preference are almost the same with the existing route except certain route. The three chosen routes prefer to use the Soekarno-Hatta road (primary arterial) rather than Lingkar Selatan road (secondary arterial) on the way to the destination. This route connects Ciwastra (residential area) in the southern suburban area of Bandung with Cijerah (residential area) in the southern suburban area of Bandung.

It can be seen from **Figure 9** for Cicadas-Elang Line (34), the three routes chosen based on user's, operator's and government's preference are different with the existing route. This route connects Cicadas as one of the highest density of residential area in the western part of Bandung with Elang as one of the highest density of residential area in the eastern part of Bandung. The existing route is passing the central part of Bandung area and hence high journey time since it is crossing the congested area. The three chosen routes are crossing the northern part of the CBD area and passing the secondary arterial road which is not congested and hence low journey time.

6. CONCLUSION AND RECOMMENDATION

6.1 Conclusion

- The concept of public transport route planning method to obtain the best route can be described as follows:
  a. The best planned routes are obtained using optimisation technique carried out by MOTORS package programme such as: the shortest, quickest and cheapest routes.
  b. The superimpose technique is used to combine all related factors such as: movement and land use pattern, population density and road network pattern as well as the coverage area with the best routes (shortest, quickest and cheapest) obtained by MOTORS to finally resulting in the most optimum and best routes giving the maximum services for users, operators and government. The Multi-Criteria analysis is being used to choose the most optimum and best routes by weighting the different preference for the users, operators and goverment. The selected criteria being used are: journey time, distance, V/C ratio and overlapped routes.

- The most optimum and best routes obtained using the Multi-Criteria technique with State-Preference approach is shown in **Table 8**. The MOTORS programme is found very useful in this study. This may due to the MOTORS programme can easily find the most advantegeous routes such as: shortest, quickest and cheapest routes.

- It is also found that some of the best corridors still have more than 2 (two) overlapped routes. This may due to there is no other alternative roads to be used by the best corridor.

7.2 Recommandation

- It is suggested that in choosing the new best routes, the future public transport demand should also taken into account so that the most optimum public transport transport service can be further obtained.

- It is recommended that the use larger public transport (medium and large public transport) to serve the future potential demand will relatively reduce the total number of fleet and hence relieve the congestion problems in the Kotamadya Bandung.

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