AN INTEGRATED PUBLIC TRANSPORT SYSTEM FOR BANDUNG (INDONESIA)

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Abstract: The population of Bandung Metropolitan Area (BMA) is over 5.5 million inhabitants and expected to reach 7 million people in the year 2000. Due to rapid development of inhabitants and the related business and industry sectors, traffic problems in Bandung is considerably becoming serious. Therefore, to relief with this growing traffic congestion, a solution towards it must be made. A comprehensive integrated transport system is thought to be essential and absolutely required.
This paper will mention in great detail an integrated urban and suburban public transport system for Bandung and its surrrounding by stressing the approach in choosing the potential main corridors (rail-based) together with their feeders (road-based). This paper will also mention outways in facing some constraints (financial, political and technical) which have to be taken in considering the potential corridors.

1. INTRODUCTION

1.1 Background

The Bandung Metropolitan Area (BMA) has an estimated population of over 5.5 million which is forecast to increase to almost 12 million by the year 2030. There is developable land sufficient to accommodate population of around 15 million at not excessive densities. In addition, the economy of Bandung is expected to grow rapidly based on diverse industrial growth, national academic and research institutes, tourism, regional administration, shopping and commercial facilities and the close proximity to Jakarta particularly when the toll roads to Bandung and Cirebon are completed.

These factors emphasise Bandung's importance now and show that it will become a major urban area in the future. There is growing awareness within Central and Local Government that existing public transport services are at present far from adequate and will not able to cope with the additional demand resulting from the rapidly expanding urban area. Some forms of public transit system will be required to serve increased travel demand and to support the development of the BMA.

Bandung is connected by national roads to Jakarta in the west via Cianjur and Cikampek and to Cirebon and southern Central Java to the east. The main traffic movements are east-west either to or through Bandung from Jabotabek. The recent constructions of the Panci Toll road by passing Bandung to the south serves the main east to west movement and will increasingly relieve Jalan Soekarno-Hatta and other through-traffic routes.

The opening of the Cikampek to Padalarang toll road section, also scheduled by the year 2000, will complete the toll road between Bandung and Jakarta and will tend to generate increasing traffic and development adjacent to the route. There will also be a significant relief to the existing Padalarang to Cikampek road and on the two alternative routes to Jakarta via Puncak and Lembang.

1.2 The Urban Context

Urban transport has many particular features which do not occur in most other types of transport situation such as inter-urban and international transport. The features manifest themselves in the form of journey to work peak hours, traffic congestion, traffic restraint measures, public transport priorities, parking policies etc. In major urban areas, rail transit systems are necessary needed to cater for the large numbers of people travelling to dense centers of attraction.

Cities that have tried to cater for private transport have all come to realise that it is not possible to build enough roads and provide enough parking space for the private cars in city centers. Particular aspects that need to be understood when planning transit and other public transport systems in urban areas in Indonesia are:

- Urbanisation is proceeding rapidly and population increases in the BMA are predicted to be high.
- Residential land development is spreading fast in outlying areas which do not have established transport links with the center of Bandung and other centers.
- Economic growth is high and is predicted to continue. This will encourage further land development and will also rapidly increase private vehicle ownership and use.
- The combination of population and private vehicle increase will cause increased road congestion. It will not be feasible to build sufficient new roads to cater for demand.
- Therefore, transport policy and provision will need to be focused on the control and restraint of private vehicles and the provision and encouragement of public transport.
- Rail and transit systems can service a significant proportion of transport demand must be planned carefully as they are high cost, inflexible and long lasting.
- Rail and transit system must be supported with an integrated plan to coordinate all transport modes and maximise the use of the systems.

2. ROAD SYSTEM PERFORMANCE

2.1 Road Network

The road network in the BMA comprises a total of 2,052 km of classified roads of which 79.2% are Class III and below, see **Table 1**. The arterial and main collector road system covers 427.4 km and the length of all arterial roads is 177.6 km. Kabupaten Bandung has the highest proportion of roads with 1138.7 km (55.5%) and Kotamadya Bandung has 796.4 km (38.8%).

The BMA contains only a small part of Kabupaten Sumedang and so the length of road is low. The existing road classification is shown in **Figure 1**. Road status is related to functional classification with primary arterials as national roads, primary collectors generally as provincial roads and secondary/local roads being the responsibility of Kotamadya or Kabupaten.

TABLE 1: Road Classification Inventory

Road Class/Status	Length of Roads (km)			
	Kotamadya Bandung	Kabupaten Bandung	Kabupaten Sumedang	Total BMA
CLASSIFICATION:				
Class I & II				
-Primary Arterial	38.9	90.0	17.0	145.9
-Primary Collector	58.3	106.7	2.5	167.5
-Secondary Arterial	31.7	-	-	31.7
-Secondary Collector	57.3	25.0	-	82.3
Class III & Below				
-Secondary & Local	610.2	917.0	97.0	1624.2
TOTAL	796.4	1138.7	116.5	2051.6
STATUS:				
National	38.9	90.0	17.0	145.9
Provincial	22.3	106.7	2.5	131.5
Kodya/Kabupaten	735.2	942.0	97.0	1774.2

Source: MBUDP (1994)

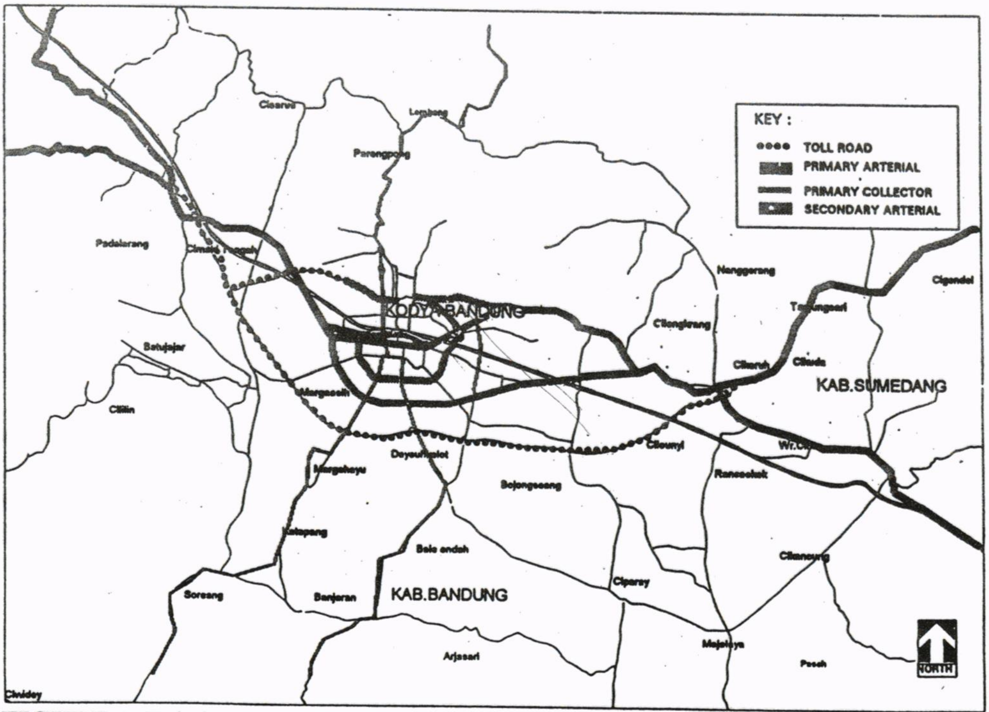

FIGURE 1: Existing Road Classification (**Source**: MBUDP, 1994)

2.2 Traffic System

a. Traffic Circulation

There is extensive use of one-way streets in Bandung. In general the existing circulation patterns are satisfactory and traffic keeps moving reasonable well. However, the one-way systems have been developed piecemeal over a period of time and result in excessive journey times and distances for many movements and particularly poor conditions for pedestrians crossing wide streams of continuously moving traffic.

b. Volume/Capacity Ratio

The operational performance of road links was considered in terms of volume/capacity ratios. The capacity of link is a function of the effective width of the link and roadside frictions that occur along the link. Existing peak hour volume/capacity ratios for Kotamadya Bandung roads are shown in **Figure 2**.

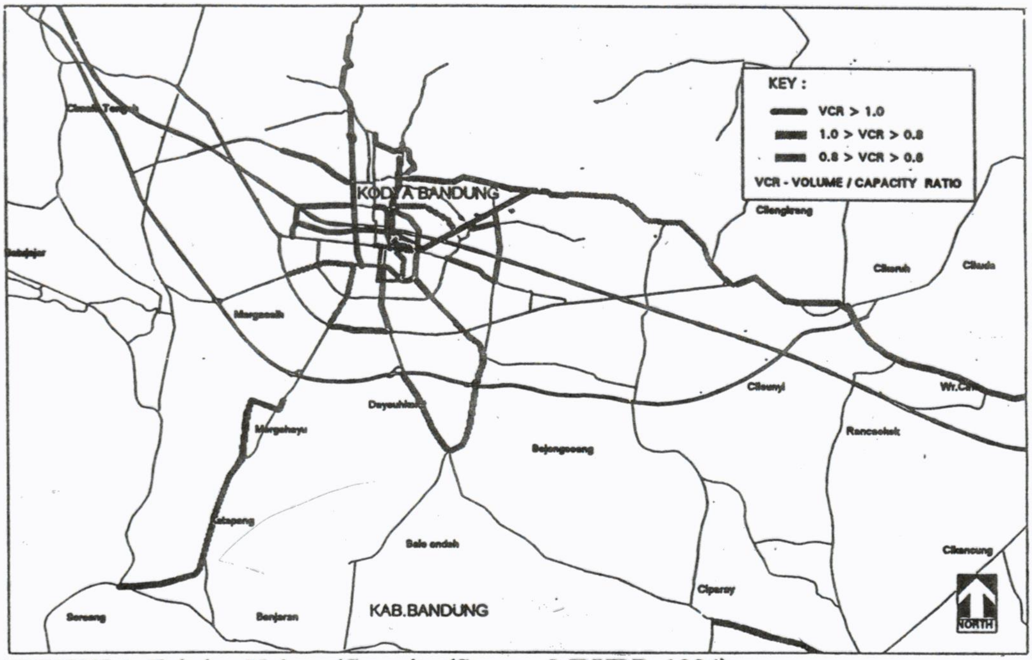

FIGURE 2: Existing Volume/Capacity (**Source**: MBUDP, 1994)

Many primary and secondary roads have volume/capacity ratios greater than one, which means the roads are overloaded, the level of service is low and delays and congestion in common place. Almost all main roads in the center of Bandung are overloaded and in the outskirts of the Kotamadya are all overcapacity in the peak hours. In the Kabupatens, traffic concentration is not so extreme although roads are overloaded in busy town center areas.

c. Traffic Speeds

Journey time surveys were carried out in 1993 **(MBUDP, 1994)** on all main roads in the Kotamadya and Kabupatens. Average journey speeds vary considerably over the BMA, depending on the road standard, degree of urbanisation, etc. and do not correlate to road classification.

Low travel speeds result from overloaded link conditions, indicated by high volume/capacity ratios and overloaded intersections. Roads with speeds less than 10 kph are regarded to have failed functionally and those with speeds less than 20 kph experience operational problems. The resulting average speeds and locations where the survey vehicle stopped for more than 3 minutes are shown in **Figure 3**.

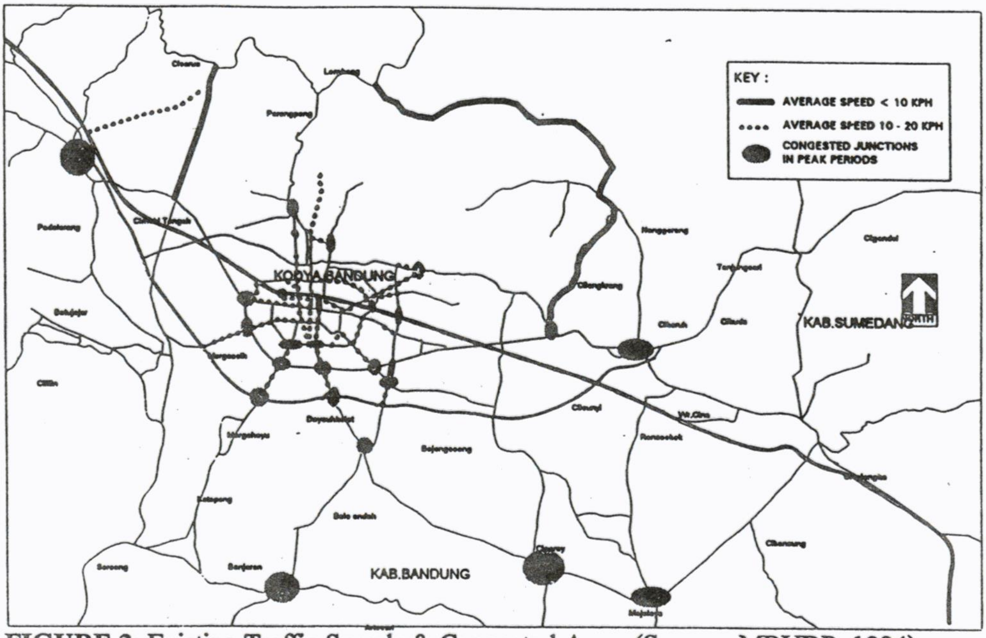

FIGURE 3: Existing Traffic Speeds & Congested Areas (**Source**: MBUDP, 1994)

2.3 Public Transport Performance

A present public transportation in the city of Bandung is mainly provided by conventional bus services, paratransits (angkots), taxis and minibuses. Angkots, minibuses and taxis are operated by independent private owners and comprise the majority of the transport services. Due to the operation of the various number of public transports in the crowded parts of the city, traffic congestions happen everywhere even on artery roads.

Motorised road-based public transport has been estimated to carry over 50% of persons traveling and from between 17%-30% of vehicles on the road during an average working day. A recent survey of public transport in the Kotamadya Bandung (**LP-ITB, 1994**) found that over a 12-hour period, the average occupancy of angkots was 8 passengers/vehicle compared with 43 passengers/vehicle for city buses.

However, it is found that angkots carry almost 4 times as many passengers as Damri buses. The operation of buses and angkots are characterised by:

a. High frequencies: every few minutes for angkots, 10 to 15 minutes for buses;
b. Low fares: Rp 150 to about Rp 500 for long journeys out of the Kotamadya;
c. Irregular picking up and setting down of angkots with no designated stops;
d. Requirement to pass through designated terminal/sub-terminal to pay fee;
e. Concentrations of angkots on high demand routes and around terminals;
f. Irresponsible and dangerous driving of buses and angkots;
g. High numbers of old, badly maintained and dangerous vehicles.

3. TRANSPORT MOVEMENT FORECASTS

3.1 Transport Needs in the Future

The future is already with us. The following trends that affect transport will continue in the future:

- People will travel more - Villagers who have never left the area of their kampung will let their sons and daughters travel 1,000s of kilometers to go to college in Bandung. Families will go across town to spend a day at the new zoo at Jatinangor. Students will go across town to attend university, and workers in the CBD and elsewhere will travel to and from housing throughout the BMA.
- More women will be working - so they will travel more.
- More people will be students - less children will start work early, more will stay at school, workers will continue to study part time. They will tend to travel to the CBD and main centers where continuing education will be concentrated.
- There will be more tourism, more hotels - more entertainment and more recreation centers. Just as people will travel more, they will also do more travel for pleasure and hence, they will need more hotels to stay in, etc.
- Most workers will be in service industries - by 2030, nationwide in Indonesia probably over 50% of the workforce, will be in service industries and the percentage in Bandung could be as high as 75% with only 5% in primary industries and 20% in secondary industries.
- Industrial production will grow but industrial employment will decline - Increasingly industries will become more mechanised even robotised. They will require less workers per unit of production but the workers will have highly specialised training for their jobs. Many factories already provide their workers with subsidised dormitory accommodation or free of charge buses to take them to and from work. As the workers get more and more specialised in their training, the factory owner will continue to provide their factory workers with accommodation or transport with accommodation or transport benefits to try to hold down labour turn over. The demand for public transport for the industrial sector will not increase significantly. Whilst public transport to the industrial areas will be needed, it usually will not be sufficient to justify special provision of public transit services.

3.2 Forecast Trips Matrices

For the central forecasts assuming an annual increase in household expenditure of 2.8%, total passenger trips in the morning peak hour are estimated to increase by 66% from 1995 to 2010 (3.42 % per year) and by 193% from 1995 to 2030 (3.11% per year), see **Table 2**. The effect of low household expenditure growth, 1.0% per year, was to reduce total trips (from the central forecast) in 2010 by 10% and in 2030 by 17%. The assumption of high household expenditure growth, 4% per year, is estimated to increase total trips (from the central forecast) by 6% in 2010 and by 4% in 2030.

The higher household expenditure growth is not shown to have a significant effect of total passengers, whereas the lower growth reduces trip totals by increasing proportions with a particularly significant reduction in the 2030 forecast year. It is also estimated that over time trips will become longer with the proportion of the shorter distance trips reducing significantly and average trips distances increasing, see **Table 3**.

TABLE 2: Forecast Passenger Trip Totals

Item	1995	2010	2030
Annual 1.0% Income Growth (Low)			
Total	442,662	660,846	1,071,924
%age	100%	149%	242%
% Increase/Year	-	2.71%	2.56%
Annual 2.8% Income Growth (Expected)			
Total	442,662	773,149	1,249,948
% Age	100%	166%	293%
% Increase/Year	-	3.42%	3.11%
Annual 4.0% Income Growth (High)			
Total	442,662	775.739	1,348,587
% Age	100%	175%	305%
% Increase/Year	-	3.81%	3.23%

Source: BMARTS (1995)

TABLE 3: Trip Matrix Distribution

Item	1995	2010	2030
Average Trips Distance (kms)	13.0	16.3	16.2
% Age of Trips < 10 kms	60%	48%	44%
< 20 kms	77%	69%	69%

Source: BMARTS (1995)

3.3 Passenger Movement Forecasts

The total passenger (car, motorcycle, bus, angkot) O-D matrices for the forecast years were analysed to understand the pattern and magnitude of the major movements and thus the potential for the transit services. In order to visualise the main movements, the BMA was divided up into seven sectors and the 90 zones O-D matrices compressed into sector movements. The seven sectors used were:

1. Old Kotamadya Bandung (plus west and south extension)
2. East Bandung (east extension of Kotamadya)
3. North Lembang-Cisarua
4. West Cimahi, Batujajar, Padalarang, Ngamprah
5. Southwest Ciwidey, Soreang, Cililin, Margahayu, dan Marga Asih
6. South and Southeast Dayeuhkolot, Banjaran, Ciparay, Majalaya
7. East Cileunyi, Jatinagor, Tanjung Sari, Rancaekek dan Cicalengka

The summary of the O-D matrix totals by sector, see **Table 4**, shows that passenger trip growth to and from the old Kotamadya area (Sector 1) will be below the average for the whole BMA, with particularly low growth in origin trips due to little or no population increase. On the other hand, East Bandung (Sector 2) shows a high increase in origin trips due to the large forecast population increase. The outer areas (Sectors 3 to 7) all show above increases in trips, particularly the western and eastern areas (Sectors 4 and 7).

TABLE 4: O-D Matrices Summary

Sector	1995		2010		2030	
	Origin	Destination	Origin	Destination	Origin	Destination
1	215,182	216,627	293,401	248,079	373,953	399,880
	100%	100%	136%	114%	173%	184%
2	69,124	59,595	140,743	94,536	339,862	162,844
	100%	100%	203%	158%	491%	273%
3	10,662	12,947	19,861	16,256	34,031	22,947
	100%	100%	186%	125%	319%	177%
4	55,895	52,737	114,630	135,004	240,648	234,395
	100%	100%	205%	255%	430%	444%
5	31,277	37,065	59,713	80,049	116,517	140,589
	100%	100%	190%	215%	372%	379%
6	41,950	47,078	77,884	116,328	140,993	241,917
	100%	100%	185%	247%	336%	513%
7	17,907%	15,948	27,222	43,202	49,107	92,539
	100%	100%	152%	270%	274%	580%
ALL	441,997	441,997	733,454	733,454	1,2295,111	1,295,111
	100%	100%	165%	165%	293%	293%

Source: BMARTS (1995)

The sector matrices are presented in the form of desire line diagrams for the years 1995 and 2030, see **Figures 4-5**. The existing dominance of Kotamadya Bandung in generating and attracting trips is demonstrated and this dominance is shown to increase in the future. The development of East Bandung will produce trips from a wide area and the east-west corridor will attract heavy demand.

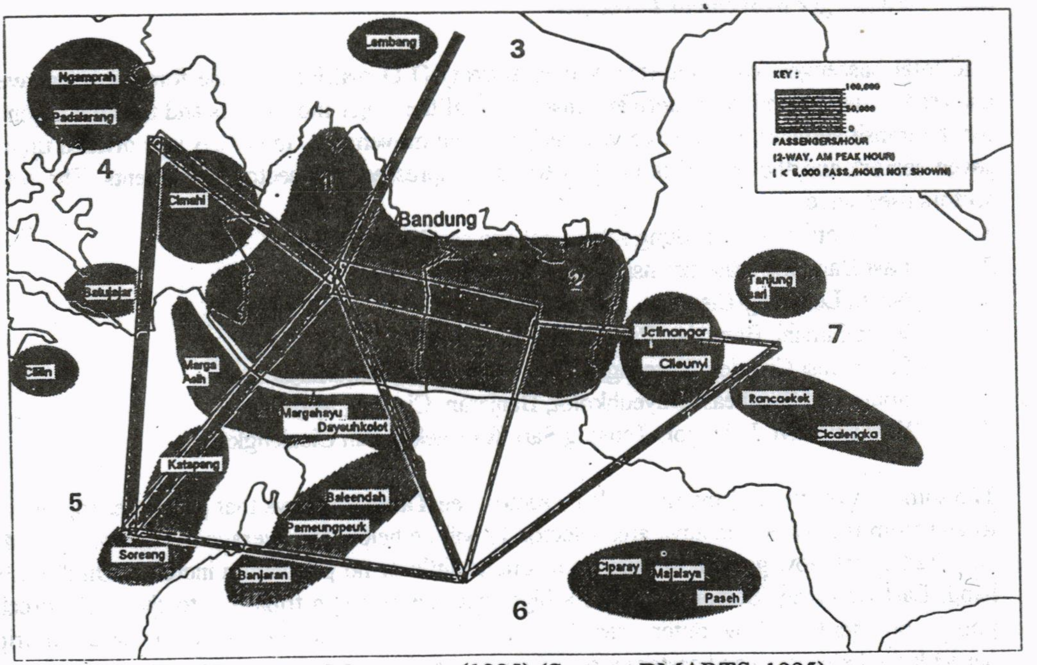

FIGURE 4: Total Passenger Movements (1995) (**Source**: BMARTS, 1995)

Peripheral movements between adjacent sectors in the western, eastern and southern areas will develop strongly in the future. Intra-sector movements comprise almost 46% of total trips in 2030 and they are particularly high for the western and southern areas (Sectors 4 and 6) and for East Bandung (Sector 2), and exceptionally high for the Old Kotamadya (Sector 1) with a total of 219,500 trips in 2030 which represents 17% of total trips in the BMA.

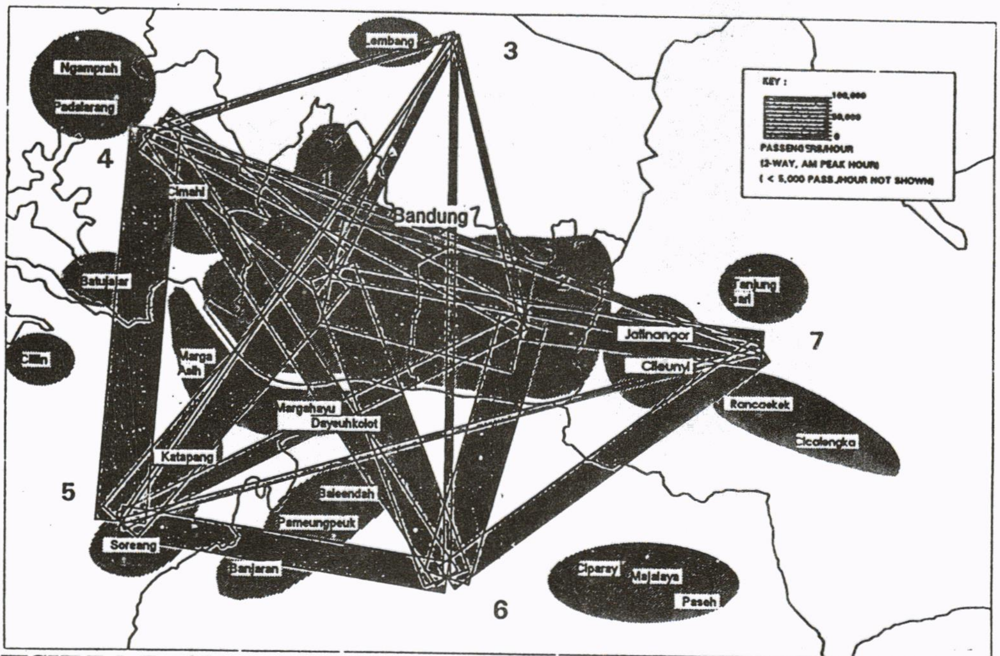

FIGURE 5: Total Passenger Movements (2030) (Source: BMARTS, 1995)

The 1995 and 2030 O-D passenger matrices were assigned to least cost routes based on an existing road network with observed speeds in order to provide more information on the location of high demand corridors for total passenger movement, and thus potential transit routes, see **Figures 6-7**.

In the base year, 1995, all peak direction passenger volumes are estimated to be less than 20,000 passengers per hour in the peak hour. By 2010, transport demand is shown to have increased substantially with peak direction volumes of 20,000-40,000 passengers per hour on many radial routes into Bandung. By 2030, transports demand is very substantial with peak direction passenger volumes up to 67,000 in the peak hour. The east-west corridor, Padalarang- Cimahi-Bandung-Cileunyi-Cicalengka is estimated to have the highest demand.

The total passenger volumes shown represent the total demand by private and public transport. The usage of different transport modes depends on various factors and the availability of different transport means is the most important factor. Other factors are: vehicles operating costs, public transports fares, etc. have a more general influence over the whole BMA.

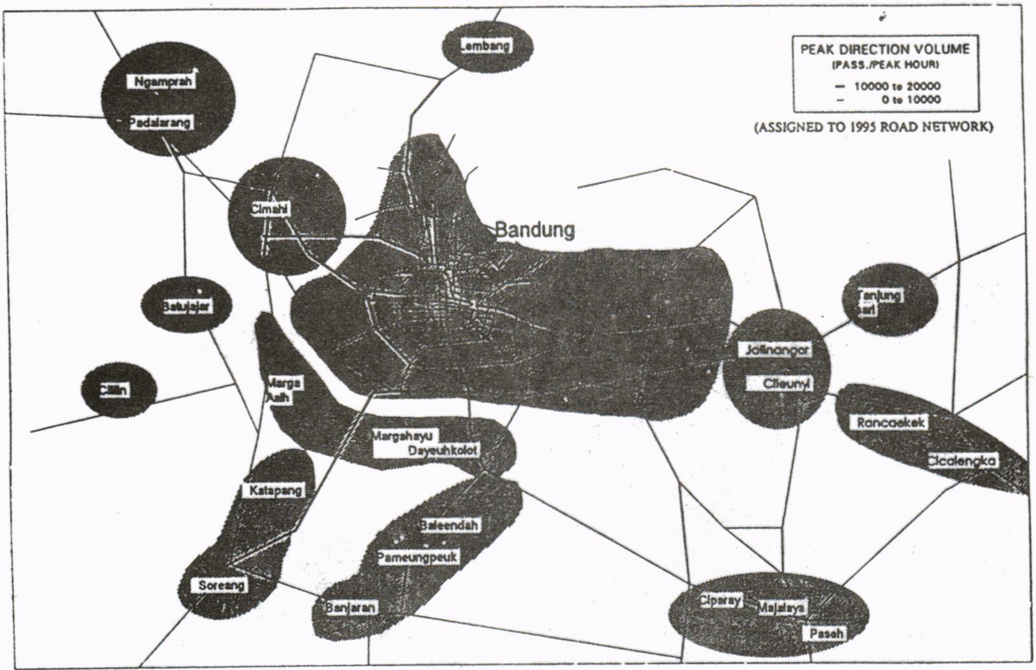

FIGURE 6: Total Passenger Volumes (1995) (**Source**: BMARTS, 1995)

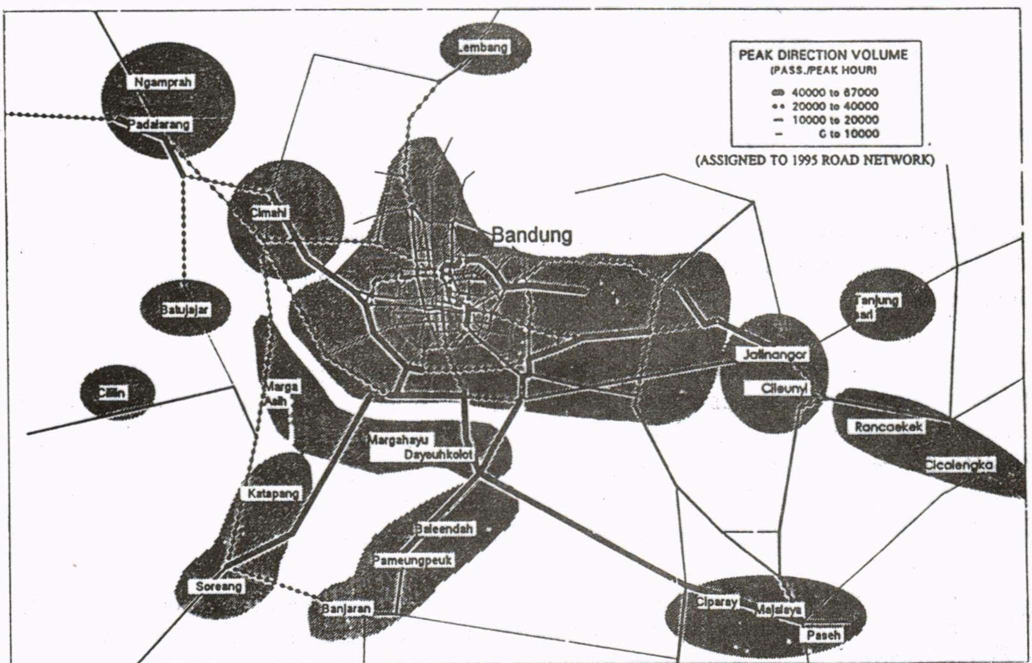

FIGURE 7: Total Passenger Volumes (2030) (**Source**: BMARTS, 1995)

3.4 Public Transport Requirements

The travel demand estimation model predicted that motorised public transport trips would increase by 88% from 1995 to 2030, see **Table 5**, with peak hours trips representing 9% of total daily trips. Public transport demand is much less sensitive to economic growth than private vehicle transport. Total peak hour public transport trips were estimated at 465,000 in 2030 for the central income growth forecast, compared with 521,000 for lower income growth and 415,000 for higher income growth.

There are currently over 9,000 licensed non-city bus public transport vehicles in the whole BMA. In order to satisfy demand, this number would need to increase to 18,000 vehicles by 2030. This level of microbus and minibus usage would not be efficient with such high demand. If all public transport demand were to be served using city buses then about 12,000 such vehicles would be required in 2030 (50 passenger capacity).

TABLE 5: Public Transport Demand

Expenditure Growth	1995	2000	2010	2020	2030
1. Low (1.0% pa)	247.000	293.000	345.000	419.000	521.000
	100%	119%	140%	170%	211%
2. Expected (2.8% pa)	247.000	299.000	347.000	405.000	465.000
	100%	121%	141%	164%	188%
3. High (4.0% pa)	247.000	298.000	240.000	377.000	415.000
	100%	121%	138%	153%	168%

Source: BMARTS (1995)

The 2030 public transport O-D matrix was assigned to the road network in order to assess the public transport requirements on individual routes and corridors, see **Figure 8**. It was considered realistic to include additional public transport trips representing the excess of private passenger trips over road capacity, 163,000 passengers/hour assuming a 1% per year increase in road capacity and peak spreading to 7% of daily volume.

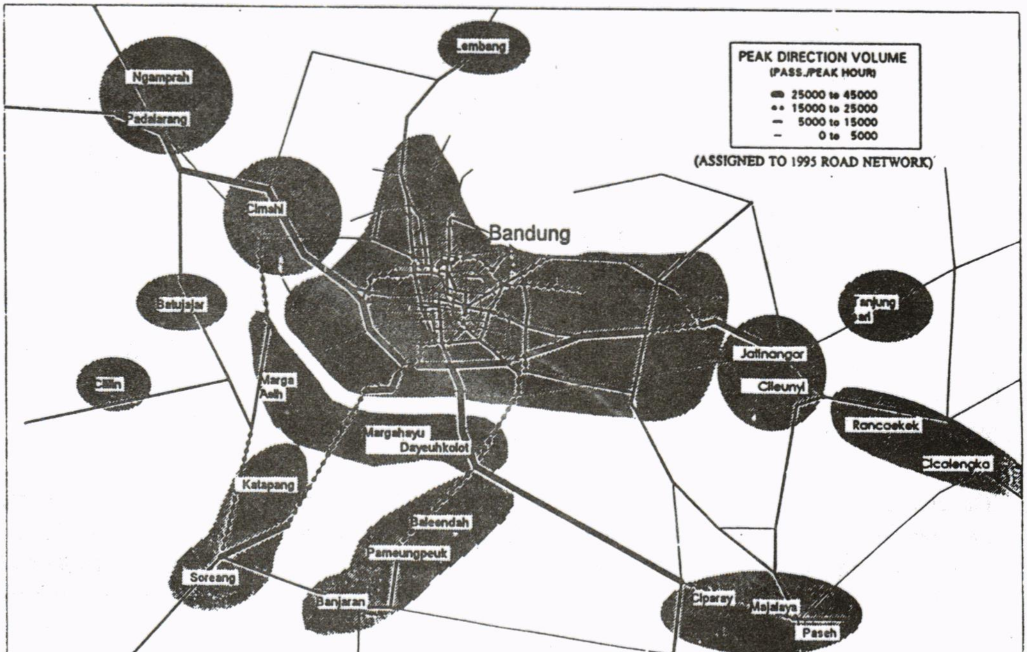

FIGURE 8: Total Public Transport Passenger Volumes (2030) (**Source**: BMARTS, 1995)

The reasonable capacity of minibus (angkot) routes is 10,000 passengers/hour and the capacity of a route utilising city buses is about 15,000 passengers/hour. It is clear that most existing angkot routes will need to be replaced with other forms of public transport to meet demand. City buses [illegible]ill provide sufficient capacity on many routes but there will also be routes on which there is potential for public transit systems, notably on the east-west corridor Padalarang to Cicalengka and routes from Soreang.

4. POTENSIAL TRANSIT CORRIDORS

The demand model has indicated substantial passenger transport movements in the future, with the following sector movements predicted to have particularly heavy demand by the year 2030:

- The East-West Corridor: Padalarang/Cimahi-Central Bandung-East Bandung-Cileunyi/ Cicalengka
- Soreang/Katapang/Margahayu-Central Bandung
- Dayeuhkolot/Banjaran/Ciparay/Majalaya-Central Bandung and East Bandung/Cileunyi/ Cicalengka
- Lembang-Central Bandung
- Within Central Bandung

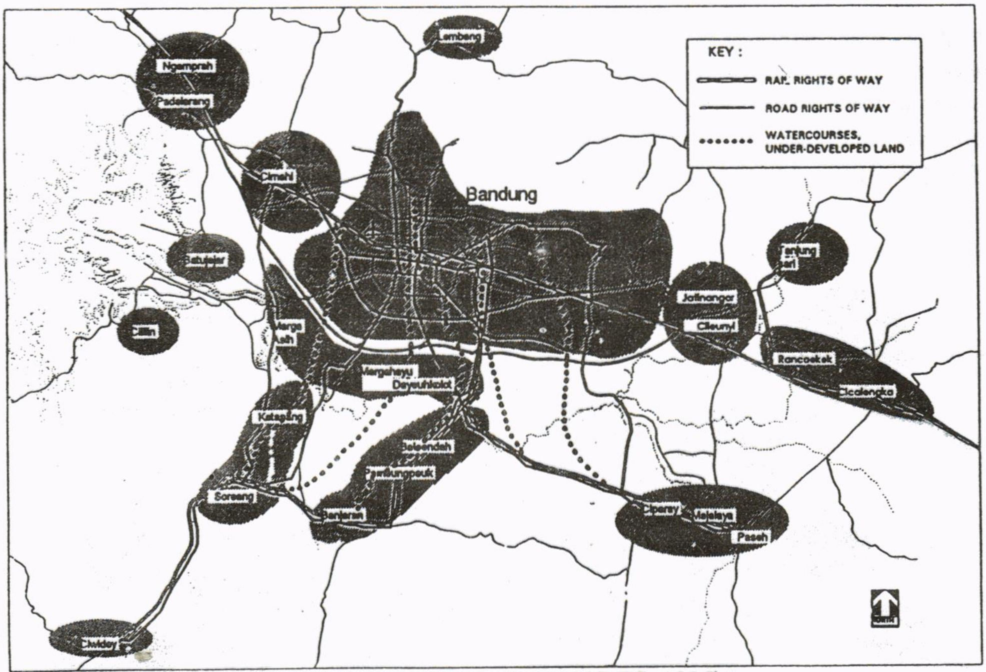

FIGURE 9: Potential Transit Corridors (**Source**: BMARTS, 1995)

The analysis of total public transport demand confirmed the potential [illegible]avy demand on the east-west corridor between Padalarang and Cicalengka and on radial r[illegible]o central Bandung from Lembang, Soreang, Banjaran and Majalaya. Having establis[illegible]at there is likely to be sufficient public transport demand over a wide area of the BMA, [illegible]e next step was to define alternative corridors for urban transit routes. By considering the [illegible]emand forecasts, available rights of way, development and other constrai[illegible]s, some possible public transit corridors were identified as shown in **Figure 9**.

By the year 2030 development in the BMA will have spread to fill almost all of the developable land area, although population densities will probably not be excessively high. The Bandung CBD area will be the focus of activity and there will be a number of major commercial/retail/entertainment centers in all the peripheral areas surrounding Bandung apart from in the north.

There will also be high activity linear corridors, mostly based on existing main radial and orbital roads. These roads will continue to serve a variety of uses including shops, offices, industry, etc. Urban transit systems are best at serving high activity linear corridors where high loadings can be achieved in both directions along the whole length of the routes.

As the BMA is likely to develop with a mixture of urban forms, it is not straightforward to identity the best type of transit system and the best location of routes. In order to work towards a viable system, four different types of transit system have been developed. The alternative systems and networks considered are as follows:

- Suburban Rail: The provision of a few main arterial, high-capacity rail lines along the most likely corridors of development served by large number of secondary feeder systems.
- Light Rail: A more extensive, segregated network of lower capacity rail lines. Other characteristics similar to suburban rail.
- LRT/Busways: The provision of a network of many medium-capacity transit systems, fed by many smaller capacity systems.
- Buses : A network of medium and large capacity diesel buses.

Estimated passenger volumes for each alternative system are shown in **Figures 10-13.**

- **Suburban Rail Network**

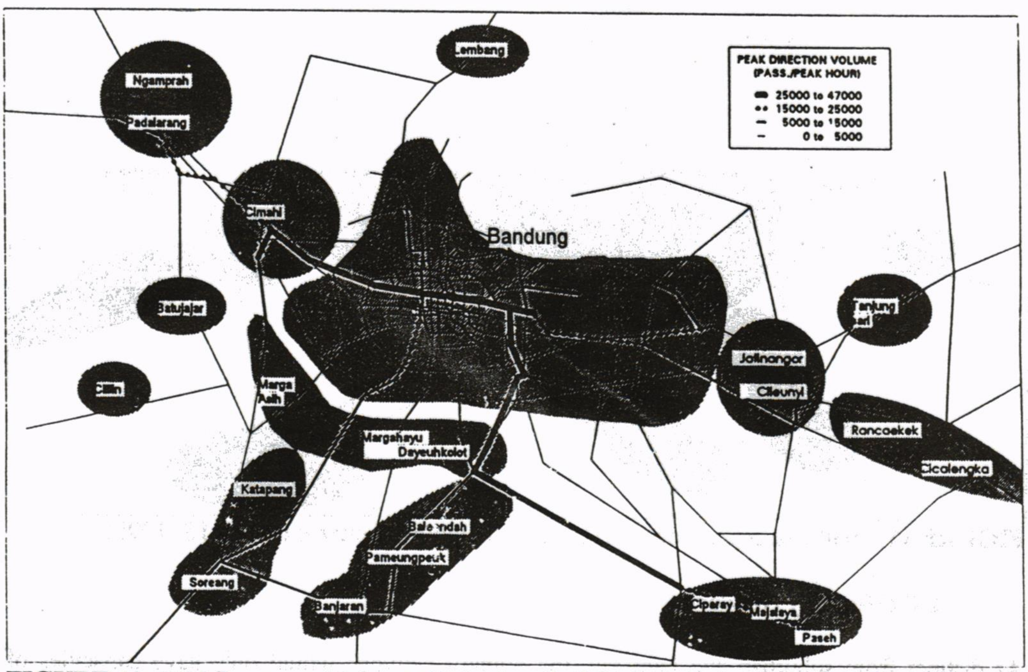

FIGURE 10: 2030 Passenger Volumes (Suburban Rail Option) (**Source**: BMARTS, 1995)

The main arterial systems would be high capacity (up to 50,000 pphpd) segregated suburban electric railways routed either on existing railway rights of way or on new alignments. Electrical Multiple Units (EMU) trains would each carry up to 2,000 passengers capable of 90 second headways. The EMU systems would be sophisticated with a state-of-the-art train control system. Such a system would be fed by either large (70-180 passengers) buses or Light Transit Vehicle (LTV's), sometimes called trams, which in turn could be fed by small buses, angkots and becaks.

The principal advantages of this type of system are a very high capacity and the fact that it does not directly affect the existing highway system. However, some highway improvements and traffic management measures would be necessary to allow the feeder systems good access to the stations. The main disadvantages of this system are the difficulty and costs of obtaining new land and the inflexibility of the system. The route system suggested for the BMA has sought to minimise the land problem by using as far as possible existing and disused rights of way.

- **Light Rail Network**

Light rail systems are similar to urban commuter railway systems except that their capacities are smaller (20,000-40,000 pphpd). They either operate on ordinary segregated railway track, usually standard gauge or on rubber tires. They can be either diesel or electric powered although the latter is preferred. The segregated light rail alternative proposed for the BMA has been designed to use available rights of way (existing and disused rail, river, drain) and presently undeveloped land and 'soft' developed land in order to minimise the land acquisition problem.

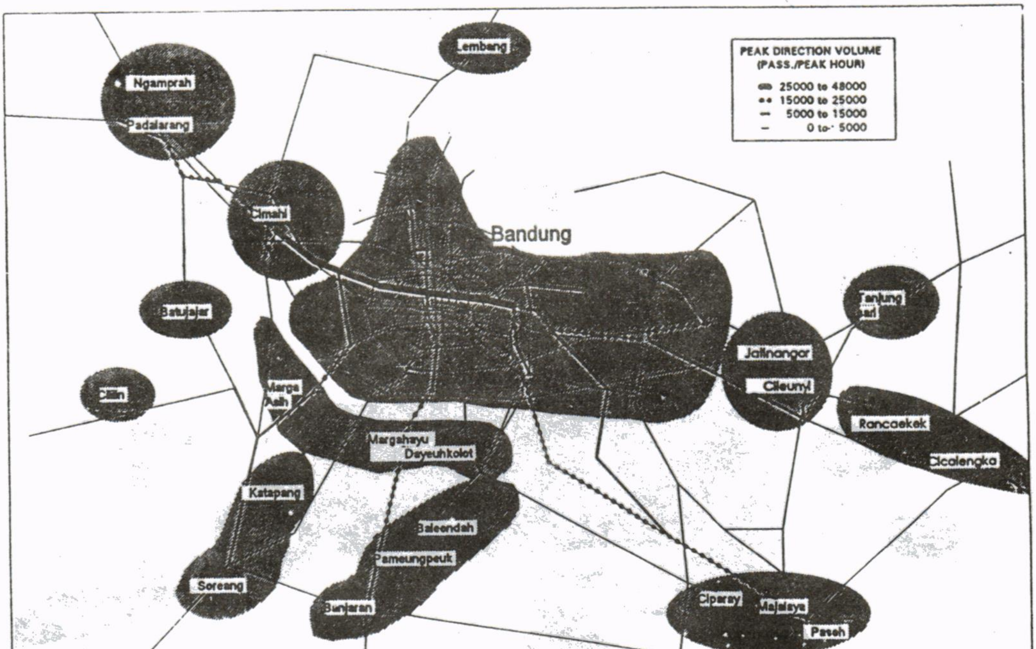

FIGURE 11: 2030 Passenger Volumes (Light Rail Option) (**Source**: BMARTS, 1995)

- **LRT/Busway Network**

As distinct from suburban and light rail, the primary network would only have capacities of between 15,000-25,000 pphpd, but the number of routes would be greater covering the metropolitan area more intensely. The system, could comprise trams (LRT), guided buses, or buses on busways, or any combination of these. If an LRT system is used, it can be either segregated or non-segregated dependent on the location and availability of highway width. Each Light Transit Vehicle (LTV) or articulated bus would carry up to 270 passengers at frequencies of 60 seconds or less.

The main advantage of these systems is that whilst they are still expensive, they are far less costly than suburban EMU systems. Also they are more flexible and more accessible to passengers making them more attractive. A further advantage of the LRT system is its ability to share to highway with road traffic when road widths are not sufficient to permit segregation from the LRT system. In city centers, the LTV's can share pedestrianised areas quite safely, and this is a very favourable feature which encourages ridership of the system.

Disadvantages of the LRT systems are their high cost (relative to buses) and the need for extensive highway works to accommodate the LTV's. The use of LRT systems necessitates the acceptance of good road discipline on behalf of road vehicle drivers and pedestrians which, in the case of Bandung, will require much re-education and acceptance of great changes to the current practices. The most difficult would be the instigation of changes in driving habits, traffic management and highway use. However, with or without any type of transit system, it will be essential for these problems to be tackled and overcome in order to solve the ever-worsening traffic congestion and pollution and to adapt to the transport needs of the future.

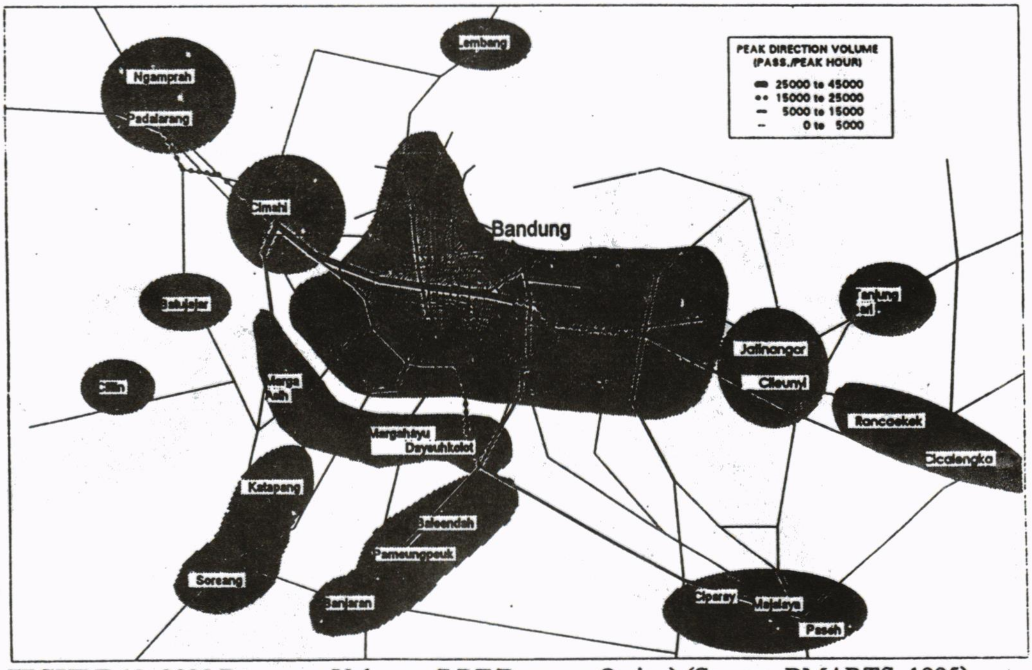

FIGURE 12: 2030 Passenger Volumes (LRT/Busways Option) (**Source**: BMARTS, 1995)

- **Bus Network**

By far the greatest percentage of local travel in the metropolitan area by angkot. It is estimated that there are about 8,600 licensed angkots making about 2 million passenger trips per day. The route capacity of angkots operating in mixed traffic is estimated at between 5,000 and 10,000 pphpd.

An entire industry exists to make, operate and maintain this large fleet of vehicles which cannot and should not, be displaced by any other system without serious consideration of the consequences. However, it is unlikely this system can be permitted to continue unchanged if the city population grows as forecast. For instance, if a route is forecast to take 40,000 pphpd, this would require 3,500 angkots passing at about one every second. This 'saturation' with angkots in inconceivable and impractical, apart from the damaging affects the fumes and pollution will have on the environment.

A simple and relatively cheap solution to the congestion problem would be to replace the angkots gradually by large buses, say 30-50 seaters. These buses could be confined to the principle radial and orbital routes, leaving the angkots to ply the secondary roads as feeders to the buses. The angkots would not be permitted to use the same roads as the buses.

However, it is estimated that for a population up to 10 millions about 30,000 buses would be required. On a 30 km cross-city route taking 30,000 pphpd , 600 buses would be required which equals one bus every 6 seconds. Whilst these figures are only indicative, they do show the size of the problems which would be inherent with very large bus systems as the fleet necessary to meet the forecast ridership will occupy too much road space, adding to the congestion.

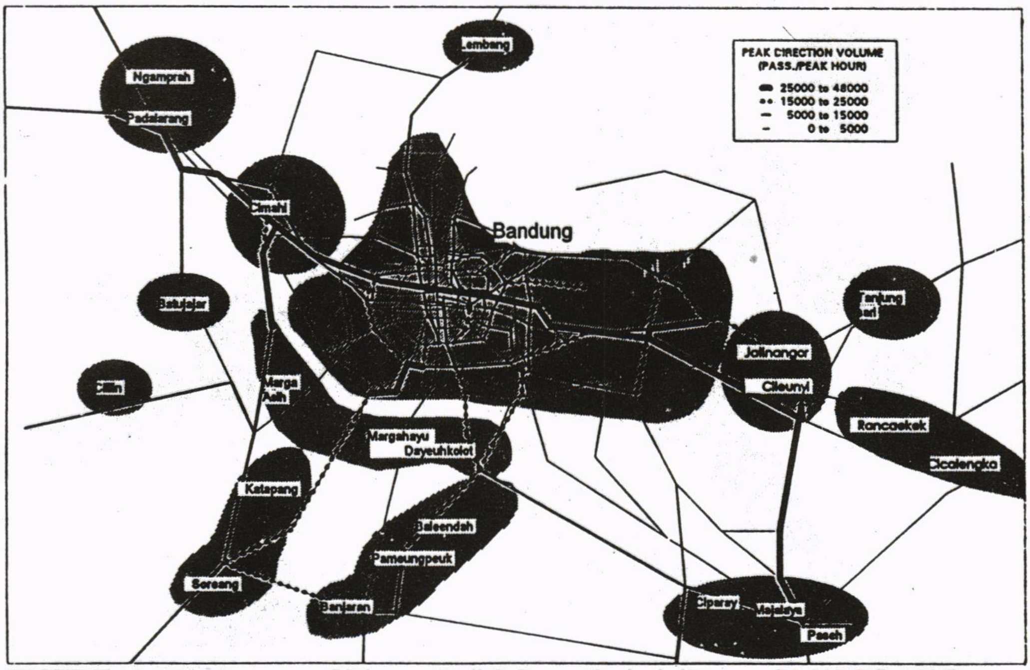

FIGURE 13: 2030 Passenger Volumes (Rail & Buses Option) (**Source**: BMARTS, 1995)

The buses would be powered by diesel engines, and although these engines are getting cleaner, they still cause excessive fumes and pollution. Bandung is situated in a hollow between mountains and the diesel fumes created would have difficulty in dispersing such that the density of pollution would become a danger to health and therefore unacceptable. There is evidence that such a situation already exists in other cities which have adopted by systems and busways and these cities are now seeking alternative solution. For the reason discussed above the use of diesels buses as medium long term solution is not recommended for the primary transit network. however conventional buses will be suitable for the secondary network and feeder routes.

5. DEVELOPMENT OF THE TRANSIT SYSTEM

5.1 East-West Corridor Alternatives

The highest transport demand is found on the east-west corridor between Padalarang, Bandung and Cicalengka and to the university and recreation area at Jatinangor. As demand is forecast to increase substantially in the future, the development of a transit system in this corridor is considered the highest priority. The presence of the existing railway right of way offers a number of alternative ways of developing a transit system:

- **Alternative 1**
  This alternative comprises the upgrading and modernising of the existing Perumka railways which would be phased over a number of years. This is a 'classic' solution, to be found in many places elsewhere in the wold. However, it is very expensive and inflexible.
- **Alternative 2**
  This is essentially the same as alternative 1 except that new main line dual tracks would be elevated above the existing tracks. This would be an expensive solution and difficult to implement and will probably be ruled out early in the feasibility stage.
- **Alternative 3**
  The concept of this alternative is that the upgrading of the Perumka services should be confined to the operation of main line, regional passenger trains and freight trains. This is the essential role of Perumka for which the administration and infrastructure was originally designed. The operations of Perumka and the transit systems would be completely separate, but both would benefit from the interchange of passengers. The urban transit services would be provided by a system which is entirely separate from the main line railway in administration and operation, since it could be standard (1435 mm) gauge or even a rubber-tyred system.
- **Alternative 4**
  This alternative is the same in all respects as alternative 3 except that the section of transit route between Kiaracondong and Cimindi is routed to south of the railway line.

5.2 Medium Term Plan

- **Types of Transit Systems**

There exists a considerable range of commercially available transit systems, in terms of both types and capacities, but the most important characteristic is capacity. It is accepted practice to state the capacity of a system as the number of passengers carried per hour per direction (pphpd). Available transit systems vary in capacity from 1,000 to 80,000 pphpd. They can be categorised as follows, although several different names are given to them:

- <u>People Mover Systems (PMS)</u>
  These can be defined as public transit systems specifically designed to carry large numbers of people, usually over short distances at frequent regular intervals,

automatically controlled and guided on segregated paths. The systems are usually elevated thus being entirely segregated from other traffic. They can be supported on either steel wheels or rubber tires, or suspended from monorails. Various methods of propulsion are used including electric motors, linear electric motors and cable-hauled. They are relatively expensive but much cheaper than mass transit underground systems.

- <u>Busways</u>
  Special segregated bus lanes providing in some cases two lanes in either direction are provided to permit buses to overtake each other and to provide an express service. Capacity depends on the amount of traffic congestion, traffic management and the reliability of the buses. The commercial speed of these systems can be very low. Whilst busways are relatively cheap and can be very effective, there is a high price to pay in terms of the environment, since the air pollution due to diesel fumes can become unacceptable.
- <u>Guided Buses</u>
  The essential characteristic of the guided bus system is that the vehicle can operate on ordinary roads in the normal manner, guided by the driver or they can be guided automatically on special paths where they are guided by several means, mechanically between kerbs, mechanically by a central rail, or electronically.
- <u>Light Rapid Transit (LRT/Trams)</u>
  A system supported on steel wheels, running on steel rails on wholly, partly or completely unsegregated right of way. They are manually driven and controlled, relying on line-of-sight to maintain distance between vehicles. The vehicles are built to a lighter standard than railway trains and can negotiate tight curves (20 m radius) and steep gradients (up to 7%). They are capable of high rates of acceleration and braking, and high speeds. A service with frequencies of 3 to 5 minutes can easily be provided and access for passengers is simple and convenient.
- <u>Light Rail (LR)</u>
  Similar to suburban rail running on existing or refurbished conventional railway tracks and use conventional electronic or color-light signalling systems. The trains are lighter-built, shorter and provide a more frequent service than suburban rail and have a similar operational performance similar to LRT. Additionally, they can be driverless - fully automatically controlled.
- <u>Urban Rail Transit (URT)</u>
  A system of urban/suburban railways, using conventional railway tracks. The vehicles are either Diesel Multiple Units (DMU) or Electric Multiple Units (EMU), the latter being supplied either by overhead or third rail. Normal railway signalling systems are used. The trains are normally manually driven although automatic control can be provided.
- <u>Mass Rapid Transit Systems (MRT)</u> - [metros, subways, underground]
  The principle characteristic of MRT is high capacity achieved by high capacity trains travelling at high overall speeds and at high frequencies. MRT routes can be elevated, at grade or underground and are normally a combination of all these. MRTs are electrically-powered, either from an overhead conductor (wire) or a third rail. MRTs are very expensive, of the order of 4 times the cost of an elevated system, and perhaps 5 to 6 times more than an at-grade system. However, there is no doubt that they provide the most efficient mode for the movement of people in urban/suburban locations.

A comparison of the capacity ranges of different types of transit systems is shown in **Figure 14**.

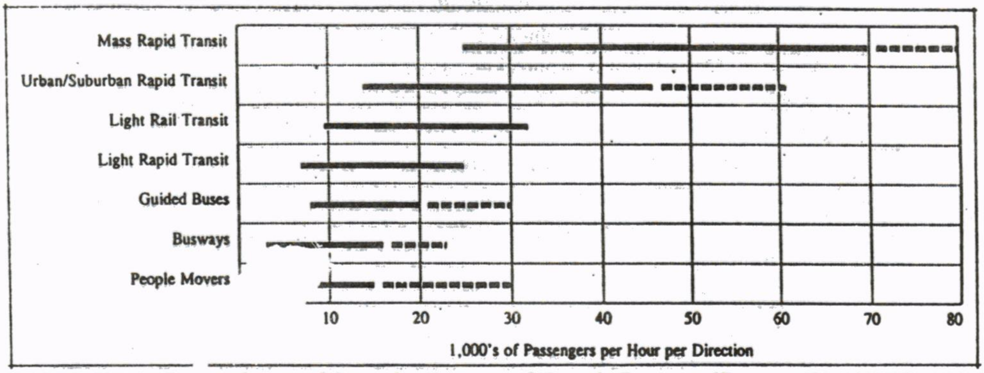

FIGURE 14: Co parisons of Capacity Ranges of Transit Systems (**Source**: BMARTS, 1995)

Technical comparisons will assist in the selection of the most appropriate systems to suit local requirements and specifications. The principle factors which will be considered in reviewing systems for Bandung include the following:

- Design Life
- Reliability and Available
- Passenger Facilities
- Performance
- Capital Costs
- Operations and Maintenance Costs

Vehicle characteristics will govern the choice of vehicle/train and these are compared in **Table 6**.

TABLE 6: Comparisons of Principle Characteristics of Transit Systems

SYSTEM		Capital Cost 2 Lanes or Guideway (USD M/km)	Operating Cost per km per Year (USD M)	Commercial Speed (Km/hr)	Maximum Speed (Km/hr)	Capacity Range (1000 pphpd)	Capacity per Vehicle/Train	No. of Vehicles per Train
i)	Minibuses (12-14 seats)	0.39-0.54	0.75-1.2	9-16	60	1.5-9	9-16	1
ii)	Standard Buses							
	- General Traffic	0.9-1.2	1.05-1.5	15	60	4-9	50-90	1-3
	- Dedicated Busways	1.2-1.5	2.1-2.8	20	60	14-19	50-90	1-3
iii)	Guided Buses (Mechanically guided)	2.5-5.8	2.7-4.8	15-25	70	19-29	50-90	1-3
iv)	People Movers (Elevated)	18-37	0.15-1.05	12-25	90	2-30	10-500	1-8
v)	Light Rapid Transit (Street running)	15-30	0.75-1.95	10-20	80	9-25	125-500	1-3
vi)	Light Rail (Segregated)	7.5-15	0.6-1.5	30-40	100	10-25	125-500	1-3
vii)	Urban Rail (Segregated)	15-23	0.6-2.25	30-40	100	14-45	125-1000	2-10
viii)	Mass Transit (Underground)	45-97	1.5-3.0	30-40	100	25-70	600-1200	6-12

(**Source**: BMARTS, 1995)

6. CONCLUSIONS

a. Public transport demand by the year 2030 is forecast to be particularly heavy in the following corridors:

- Padalarang, Cimahi, Central Bandung, East Bandung, Cileunyi, Cicalengka.
- Soreang, Katapang, Margahayu, Central Bandung.
- Banjaran, Dayeuhkolot, Central and East Bandung.
- Ciparay, Majalaya, Central and East Bandung, Cileunyi, Cicalengka.
- Lembang, Central Bandung and within Central Bandung.

b. Strategy networks have been devised corresponding to different types of transit system. Each alternative corresponds to a primary system which would be integrated with an extensive secondary system providing feeder services to the transit system and general urban public transport:
- Suburban Rail
- Light Rail
- LRT/Busways
- Buses

c. Passenger volume forecasts of 25,000-47,000 passengers/hour in the peak direction indicate that by 2030 a suburban rail service and/or a high capacity transit system would be well justified for the east-west corridor.

d. High cost, high capacity suburban rail may not be required in other areas, and lower capacity light rail systems would probably be sufficient to meet capacity needs.

e. Both the LRT/Busway and conventional buses alternatives show variable demand with some sections having low passenger volumes and other sections indicating the need for higher capacity systems.

f. Each of the strategy alternatives is proposed to be taken forward to feasibility studies when more detailed passenger volume forecasts will be made, an optimum composite strategy will be formulated and staging proposals made.

g. Land acquisition acceptability and cost could well rule out new transit routes through built up areas. As far as possible the strategy alternatives have been located on the most feasible routes such as: existing and disused railway rights of way, road rights of way, watercourses and underdeveloped and undeveloped land.

h. In the CBD and other inner city areas, consideration will need to be given to elevated or underground construction to overcome the problems of land acquisition. However, construction costs for elevated rail transit tracks are around twice that for at-grade construction and about four times for underground construction.

i. The existing railway is recommended to be upgraded to provide better main line and regional services.

j. A separate transit system, following the existing railway wherever possible, should be built to serve commuter and short distance passenger demand.

k. The transit system should be physically and operationally separate from the existing railway.

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