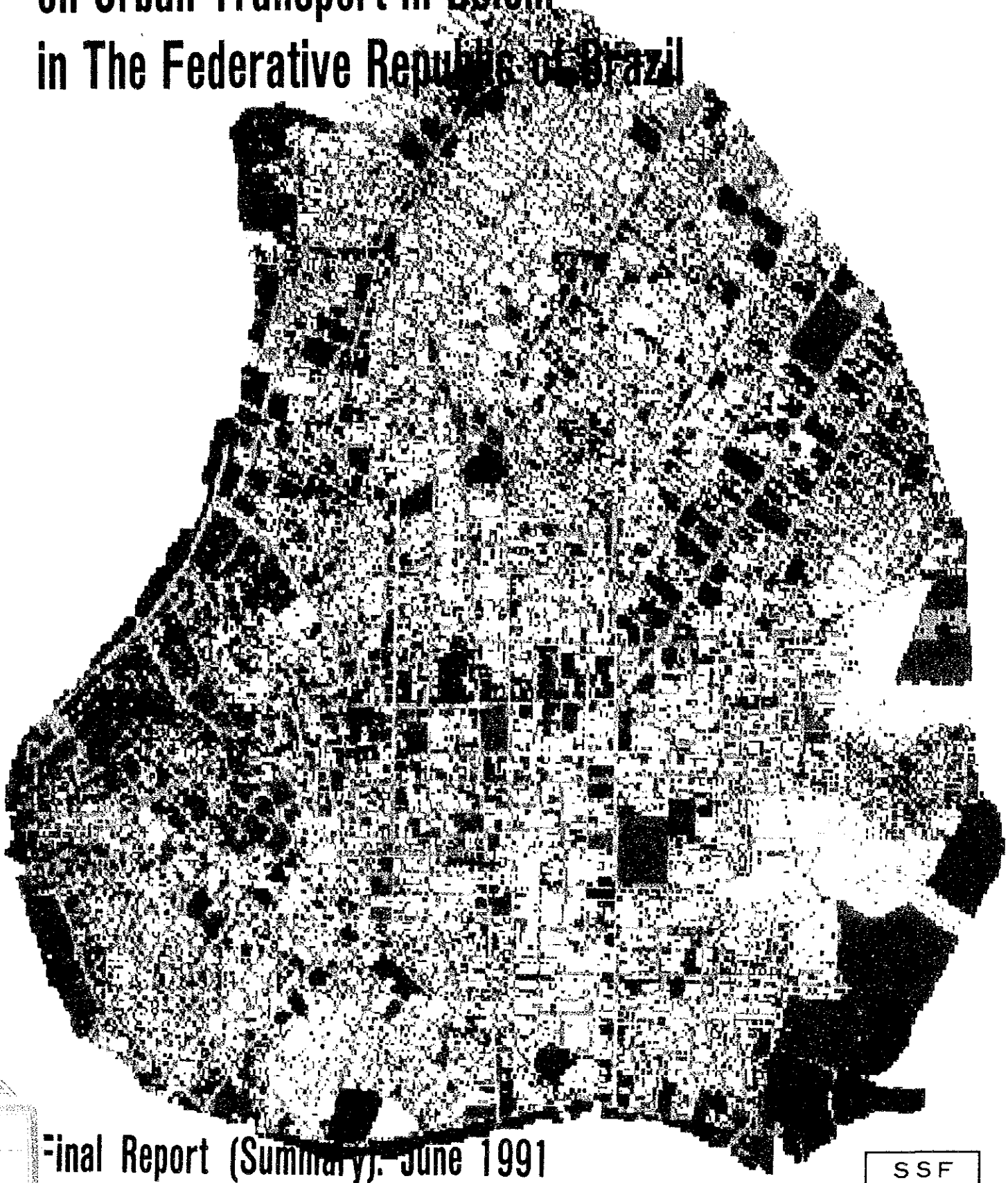
社会開発調査部報告書

No. 52

The Masterplan Study on Urban Transport in Belem in The Federative Republic of Brazil



Final Report (Summary): June 1991

Japan International Cooperation Agency

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PREFACE

In response to a request from the Government of the Federative Republic of Brazil, the Government of Japan decided to conduct a Masterplan Study on Urban Transport in Belem and entrusted the study to the Japan International Cooperation Agency(JICA).

JICA sent to Brazil a study team headed by Mr. Takeo Sato, Chodai Co., Ltd., composed of members from Chodai CO., Ltd. and Yachiyo Engineering Co., Ltd., three times between October 1989 and March 1991.

The team held discussions with the officials concerned of the Government of Brazil, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Federative Republic of Brazil for their close cooperation extended to the team.

June 1991

Kensuke Yanagiya
President
Japan International Cooperation Agency

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1. INTRODUCTION

1.1 Background

Belem, the largest metropolis in Amazon area, is the capital of Para state, about 1600km north of Barsilia. Its development was brought about by the advantageous location of the gate port of the Amazon basin, situated about 130km upstream from Atlantic Ocean. The Belem Metropolitan Region (BMR) consists of Municipalities of Belem, Ananindeua, Benevides and Barcarena.

Due to the influx of a large number of immigrants to the Reagion, its population has been growing at an average high of about 3.4% annually for the past several decades. It is expected to grow from 1.4 million in 1990 to about 2.4 million in the year 2010.

The economic growth of Para State which includes Belem Metropolitan Region, has been stagnant in recent years, due to the country-wide economic recession. GRP (Gross Regional Products) growth rate from 1979 to 1989 was 6.44% per annum, however, from 1987 to 1989 the GRP was 3.32% per annum. Due to the economic recession of the Region, the vehicle ownership of the Region increased slightly from some 67.7 vehicle per thousand persons in 1980 to 71.2 vehicles per thousand persons in 1989.

Urban area in Belem Metropolitan Region (BMR) has been expanding rapidly in accordance with the population growth of the BMR. The Central Area, namely the Belem District, which has been developing since the early seventeenth century, has the major business, commercial and government administrative functions, as well as the residential one. This District is surrounded by rivers (south and west) and the Institutional belt (military and government use, north and east).

High income people are concentrated in the limited area of the Belem District with the high rise buildings and dense population. On the other hand, low income people live outside the Institutional belt. The huge area along Augusto Montenegro Rd. and National Road BR-316 have been developing in response to the residential demand of those people for the past two decades.

Due to the high growth in population and vehicle number, the traffic demand has growth rapidly. The main traffic corridors in the urbanized area of the Region suffer from congested traffic, due of the excessive concentration of the urban functions into the Central Area, insufficient number of the traffic corridors and the reduced traffic capacity of the streets due to car parking and/or bus operations for passenger movements.

The bus transport, which is the major transport mode for person trips, has developed in terms of service area and number of bus operations in response to the expansion of the urbanized area. Buses are operated by nineteen (19) private companies mostly serving to the Central Business District (CBD), located at south-west corner of the Belem District.

There are some seventy (70) bus routes covering the urban area of the Region. These routes concentrate into a few traffic corridors for revenue reason and/or road network condition. The bus operation network does not sufficiently cover the newly developed area, especially the one outside the Institutional belt. People are forced to commute and/or to travel by poor transport means every day.

In view of above problems, it is imperative to improve the urban transport system in Belem Metropolitan Region. To carry out the above program effectively, it is necessary to establish a master urban transport plan including a future land use plan for the Region.

With above objectives in mind, the Government of Brazil requested the Government of Japan for assistance to conduct the Masterplan Study on Urban Transport in Belem in 1988. In response to this request, the Government of Japan through its implementing Agency, the Japan International Cooperation Agency (JICA) began to carry out this study jointly with the Government of Brazil since November, 1989.

1.2 Objectives of the Study

The objectives of the Study is to formulate a transport masterplan including transport policies, a development plan and program for the short and long terms, and a future land use plan in the Study Area, that will effectively serve the present and future transport demands and contribute to urban development in the Belem Metropolitan Region.

1.3 Study Area

The Study Area covers the present and future urbanized area of the Municipalities of Belem and Ananindeua, shown in Figure 1.3-1. Although Belem Metropolitan Region includes also the Municipalities of Benevides and Barcarena, the Study Area did not cover these area which are located independently from the Belem urban area.

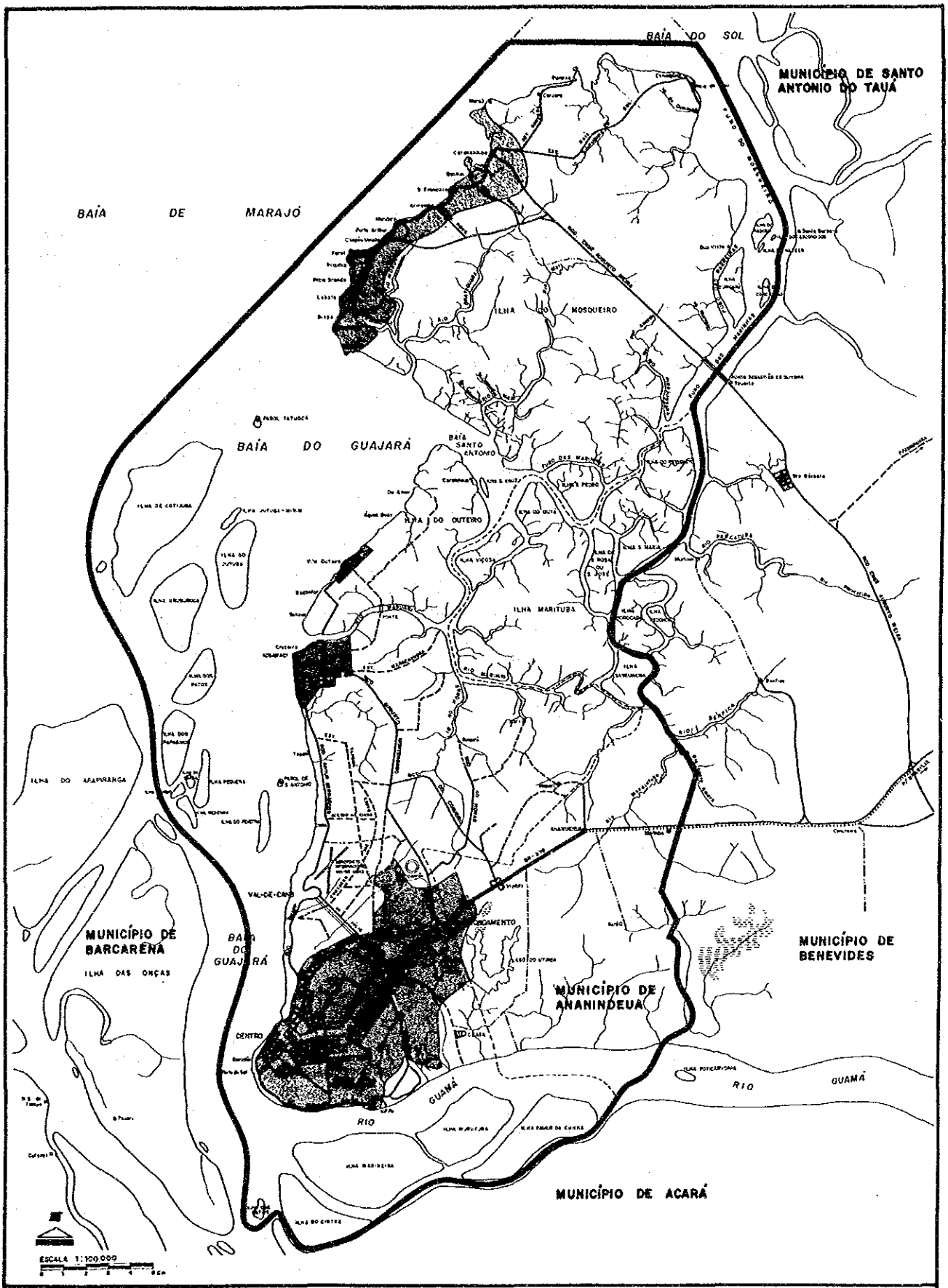

Figure 1.3-1 Study Area

2. SOCIOECONOMIC TREND

2.1 Population

2.1.1 Population Growth Trend of Study Area

As shown in Table 2.1-1 the population of the Study Area has increased from 996 thousands in 1980 to 1,419 thousands in 1990 at an annual increase rate of 3.6% on the average. This value is 0.7 percent lower than that of 4.3% in the 1970s.

Table 2.1-1 Population Growth the Study Area

Year	Pop.(thousand)	Annual Increase Rate(%)
1980 1)	996	
		3.61
1990 2)	1,419	

Source:1) Enumeration from 1980 Census Tracts Data (The value is about 3 thousand persons smaller than the official summed value of 999 thousand for the municipalities of Belem and Ananindeua. These persons are considered to have been in the islands outside of the Study Area.)
2) Result of household data by PT Survey (April, 1990)

The net in-migration rate has been fluctuating between 1.0 and 1.5% per annum. No clear trend of change can be observed, but in recent years it seems that the rate has ranged at a level of 1.4 to 1.5% and the annual in-migration is nearly 20 thousand persons larger than the out-migration (refer to Table 2.1-2).

Table 2.1-2 Estimated Population Increase Rate of Brazil and Natural Increase Rate of the Study Area

	Population Increase 1) Rate of Brazil	Natural Increase Rate of Study Area
1980/81	2.29	2.81
1984/85	2.19	2.28
1989/90	2.01	1.86

Source: 1) IBGE

2.1.2 Demographic Structure in 1990

Of the total population of 1,419 thousand, 670 thousand are males and 749 thousand are females. The number of male population per 100 females (sex-ratio) is 89.5. The age-sex composition is shown in Figure 2.1-1. Males exceed females in 0-4 and 5-9 years age-groups. In all other age-groups, however, there is an exceed of females over males. As for the age structure, the compositions of the age-group 15-19 years are the highest at 13.1% of the total.

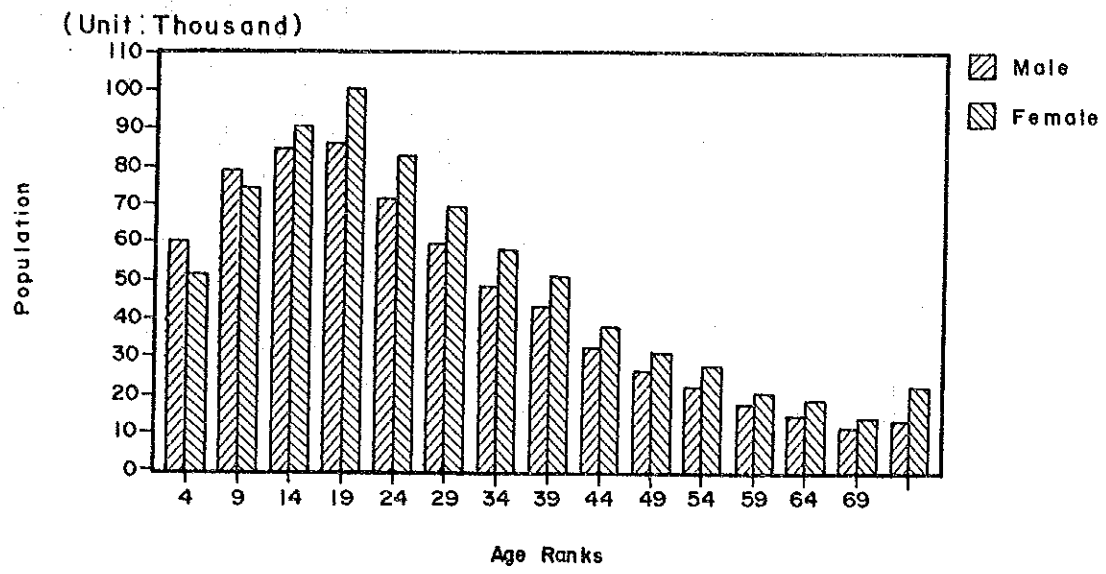

Figure 2.1-1 Population by Sex and by Age-group

The economically active population (labor force) is 541 thousands. The population not in labor force comprises of 414 thousand students, 200 thousand housewives and 264 thousand others (refer to Table 2.1-3).

Table 2.1-3 Economic Participation

Economic Category	Number	Percent
Economically Active	541,000	38.1
Employed	494,000	34.8
Unemployed	47,000	3.3
Not Economically Active	878,000	61.9
Students	414,000	29.2
Housewives	200,000	14.1
Others	264,000	18.6
Total	1,419,000	100.0

2.2 Gross Regional Product (GRP)

2.2.1 Economic Growth of Brazil and Para

The Brazil economy suffered from a series of difficulties in the 1980s. The annual average growth rate of GDP was only about 2.2% during the past ten years, extremely lower than that of 8.6% in the 1970s. The State of Para is typical frontier area of the national economy. The investments in the sectors of energy and mining have contributed to a relatively high economic growth.

Table 2.2-1 Annual Growth Rate of GDP and GRP of Para (%)

Year	GDP(Brazil) 1)		GRP(Para) 2)	
1981	-4.4		-1.3	
1982	0.6		7.3	
1983	-3.5		-2.7	
1984	5.1		5.9	
1985	8.3	1.1	3.8	2.5
1986	7.5		17.1	
1987	3.6		2.1	
1988	0.0		5.0	
1989	3.3	3.6	2.9	6.6
1980-1989		2.2		4.3

Source: 1) IBGE, 2) IDESP

2.2.2 Estimation of GRP of the Study Area in 1989

There are no published data of GRP of the Study Area. However, it can be estimated by using the data obtained from the economic censuses (IBGE 1975/1980) as shown in Table 2.2-2.

Table 2.2-2 Estimated GRP of the Study Area in 1989 (US$ 1000, %)

Sector	Amount	Percentage
Primary	10,702	0.3
Secondary	951,378	27.8
Tertiary	2,454,476	71.8
Total	3,416,556	100.0

2.3 Household Income

According to Person Trip Survey, the number of households by monthly income level is shown in Figure 2.3-1. Most households earn under 30,000 NCZ per month (as of March,1990).

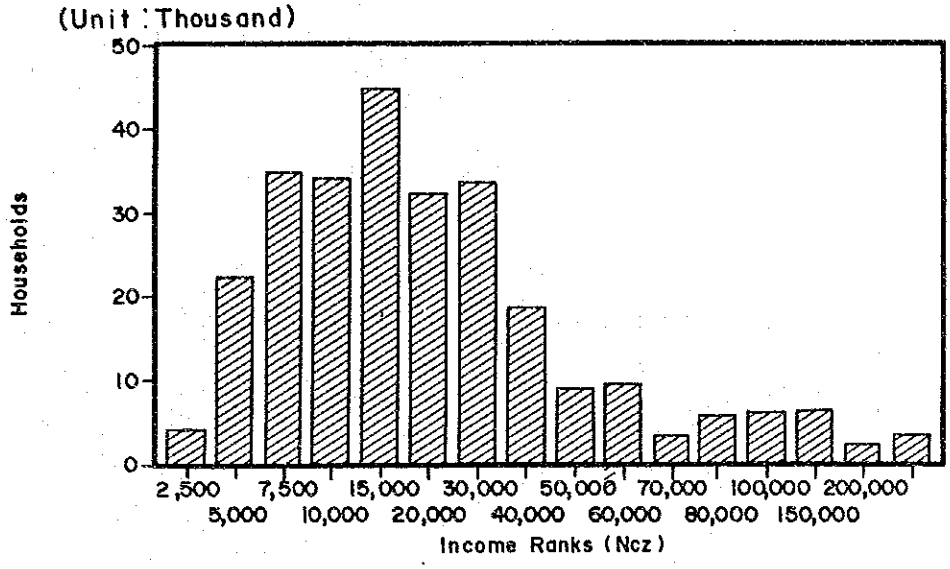

Figure 2.3-1 Monthly Income Distribution

The ratio of the total income earned by each quintile group to the whole regional income distribution is shown in Table 2.3-1.

Table 2.3-1 Average Monthly Income and Composition of Income Distribution by Quintile Groups

Monthly Income Quintile Group	Average Monthly Income (NCZ)	Composition of Income Distributed (%)
I	5,093	3.3
II	9,507	6.2
III	15,606	10.3
IV	26,707	17.6
V	95,252	62.6
Total	30,433	100.0

2.4 Car Ownership

According to Person Trip Survey, the total number of cars is approximately 69,000 vehicles. On the other hand, the figure for motorcycle (4,800) is much lower than that of cars (as of march,1990). Adding some of the cars owned by companies or government to the survey data, the total number of cars is estimated approximately 98 thousands. There are clear correlation between household income level and car ownership as shown in Figure 2.4-1. The ratio of car ownership raises in accordance with the increase of income level.

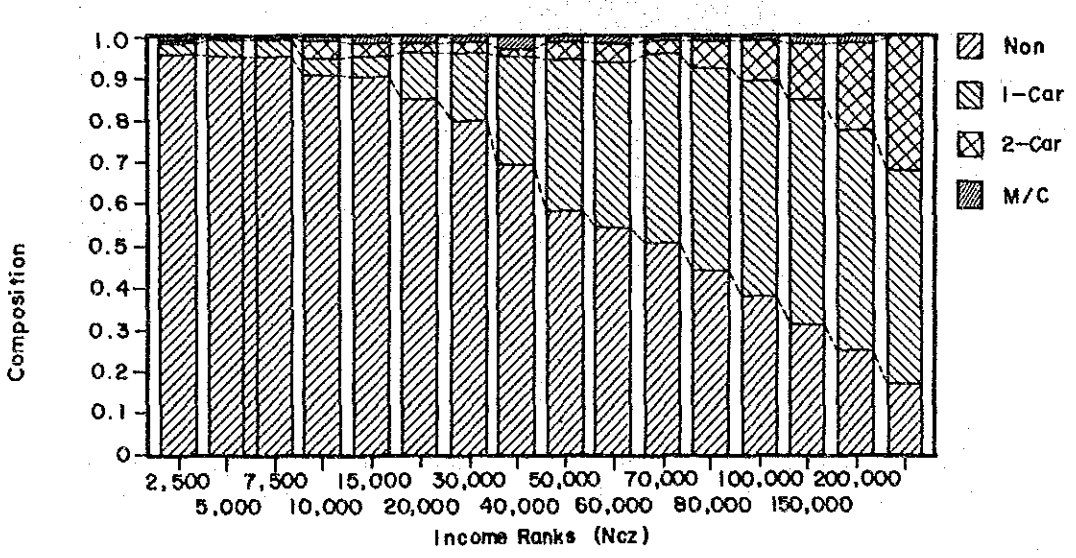

Figure 2.4-1 Accumulative Percentage of Car Ownership

3. EXISTING LAND USE

In accordance with the characteristics of the lands and the historical backgrounds of urban evolution, the Study Area is designated into four (4) parcels as shown in Figure 3-1. Quantifying of land use was carried by each designated area from the land use survey (refer to Table 3-1).

Table 3-1 Area List of the "General Land Use Survey"

Zones	Central area	Transition area	Expansion area	Islands area	Total (C)	Total (W)
Consolidated urban zones	35.24	5.69	23.57	5.00	64.50	69.50
Urban zones in formation	-	5.21	43.70	12.00	48.91	60.91
Industrial zones	0.61	-	14.87	0.50	15.48	15.98
Residential estate zones	-	3.58	15.27	-	18.85	18.85
Institutional zones	1.28	34.18	23.26	1.00	58.72	59.72
Rural zones	-	-	105.18	297.37	105.18	402.55
Total	37.13	48.66	225.85	315.87	311.64	627.51

Note: Total(C) = Continental area, Total(W) = Whole Study Area

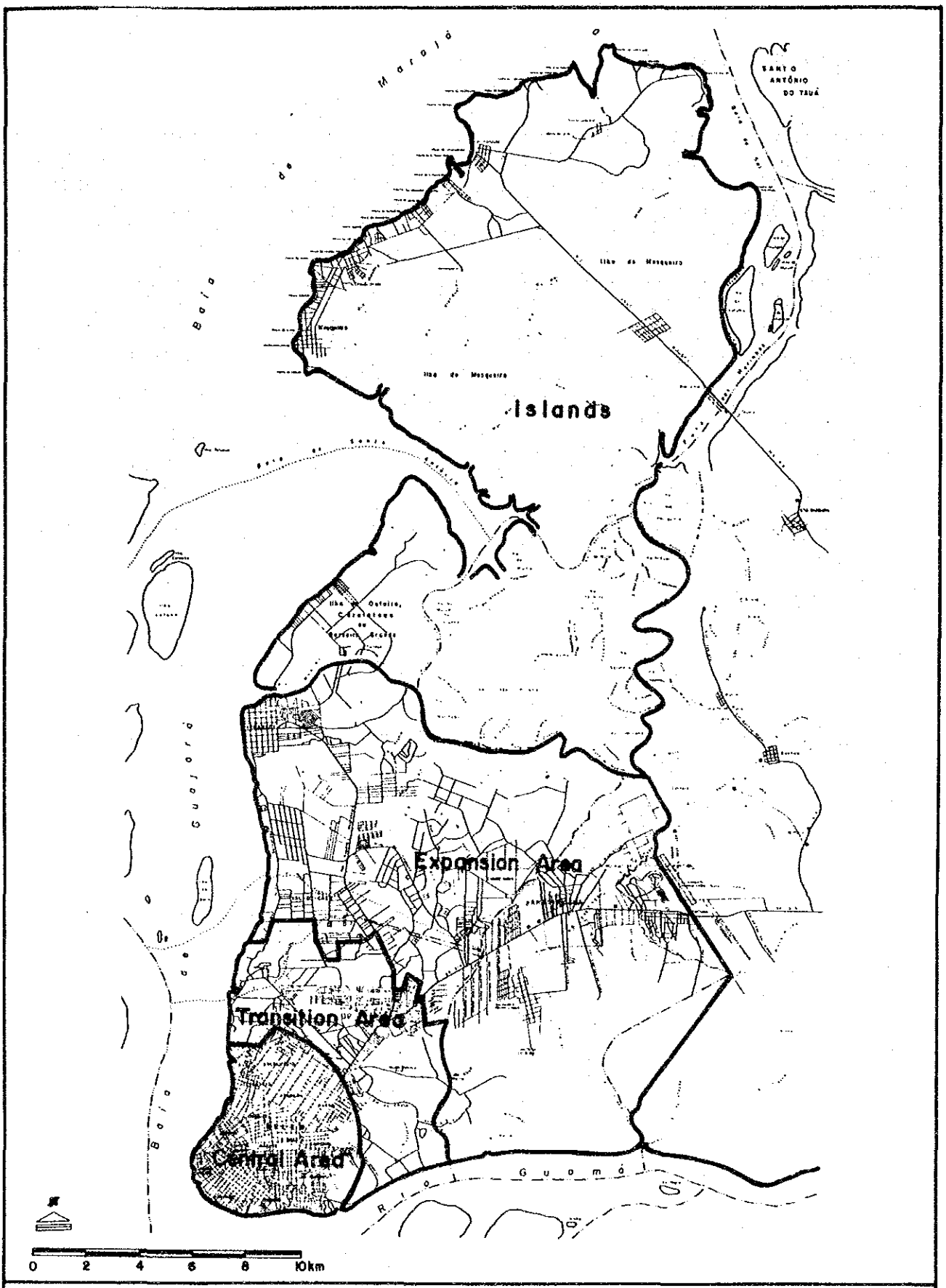

Figure 3-1 Area Designated for Land Use Study

Approximately 95% of the Central area is composed of Consolidated urban area. On the other hand, in the Expansion area, only 10% of the total area is of Consolidated urban area. 70% of the Transitional area are accounted for Institutional zones and only a few percent are constituted for urban area.

Table 3-2 shows the number of population from 1940 to 1990 by decades. In Expansion area, population notably grows since 1970.

Table 3-2 Succession of Population

(unit: persons)

Areas	1940	1950	1960	1970	1980	1990
Central area	168,000	215,449	334,961	504,904	645,556	712,593
Trans. area	2,000	14,000	33,000	85,000	150,000	205,818
Expan. area	17,436	22,243	35,484	62,747	203,114	484,107
Islands	8,000	10,000	11,000	13,000	16,753	16,706
Total	195,436	261,692	414,445	665,651	1,015,423	1,419,224

Sources: Years of 1940 to 1980 are determined from IBGE data.

In 1990, population density of Central area reached 198.8 person/ha, and Transition area also counts 142.1 person/ha in net case, while Expansion area counts only 23.9 person/ha.

4. EXISTING TRAFFIC CONDITION

4.1 Traffic Volume

The daily traffic flow based on the road section and intersection traffic counting, in the Study Area, is shown in Figure 4.1-1. The highest traffic flow is observed on the corridor of Av. Almirante Barroso - BR-316, and at the beginning point of BR-316 (Entroncament), the daily volume is around 56,000 veh/day. This huge volume does not fluctuate much throughout the section from Sao Braz to the intersection with Coqueiro road where the traffic from Cidade Nova estate merges.

Av. Pedro A. Cabral, where was constructed in order to divert the traffic from Av. Almirante Barroso, handles 1/3rd of the traffic on Av. Almirante Barroso or 17,000 veh/day because of the existence of unpaved section (at survey time).

The streets with the higher traffic volume in the urban area are;

a.	Av. Nazare	: 30,000 veh/day
b.	Av. Padre Eutiquio	: 28,000 veh/day
c.	Av. Presidente Vargas	: 30,000 veh/day
d.	Av. Generalissimo	: 28,000 veh/day

The roads with the higher traffic volume in the suburban area are;

a.	Rd. Augusto Montenegro	: 8,300 veh/day
b.	Rd. Coqueiro	: 16,000 veh/day

4.2 Hourly Fluctuation of Traffic Volume

Figure 4.2-1 shows the hourly fluctuation of traffic volume by each direction and both directions. The inbound traffic flows from suburban area show the peak period during 7:00-8:00 in the morning, while the outbound flows show during 12:00-13:00 and 18:00-19:00 in the evening.

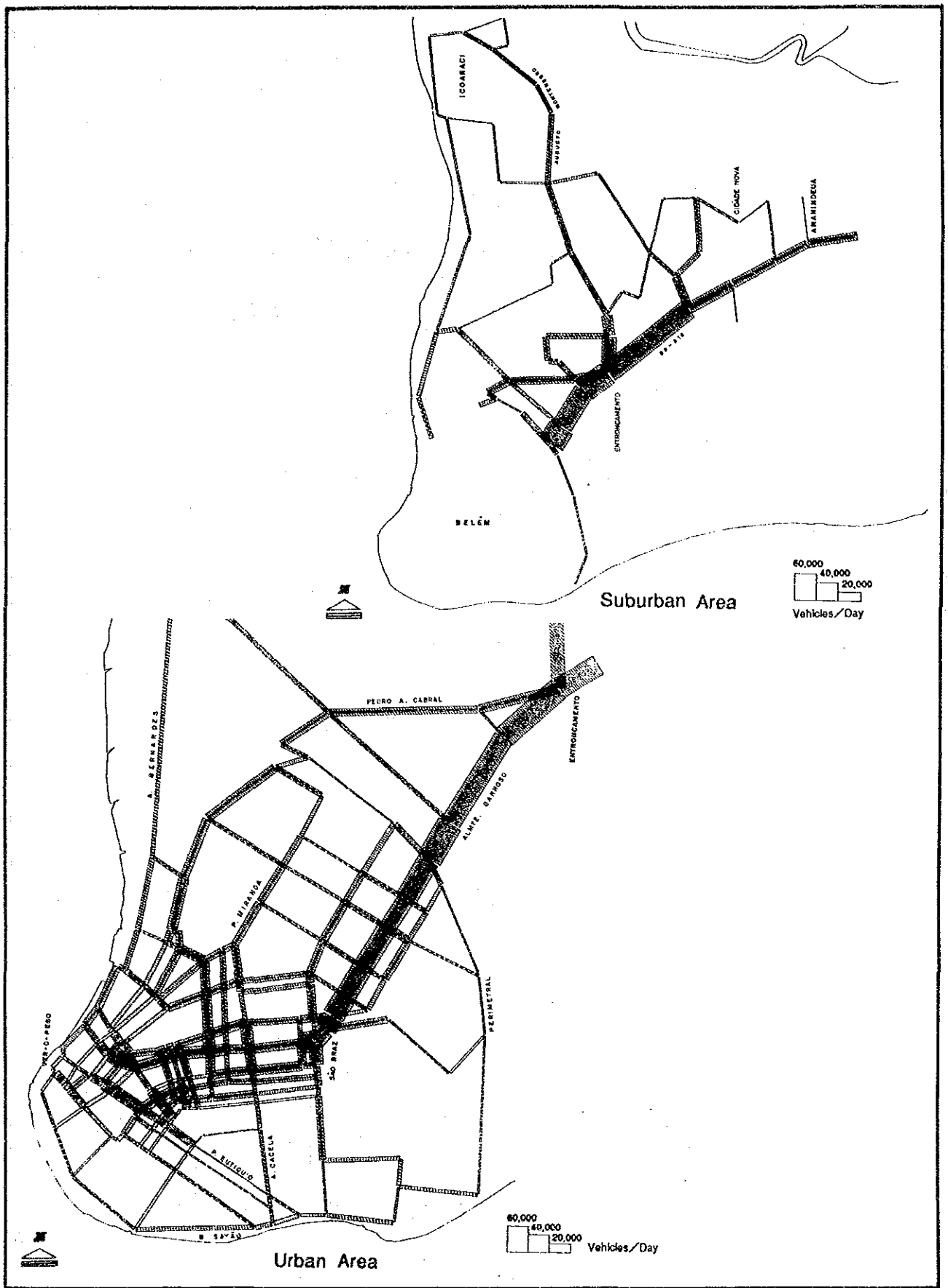

Figure 4.1-1 Traffic Volume Diagram on Major Roads

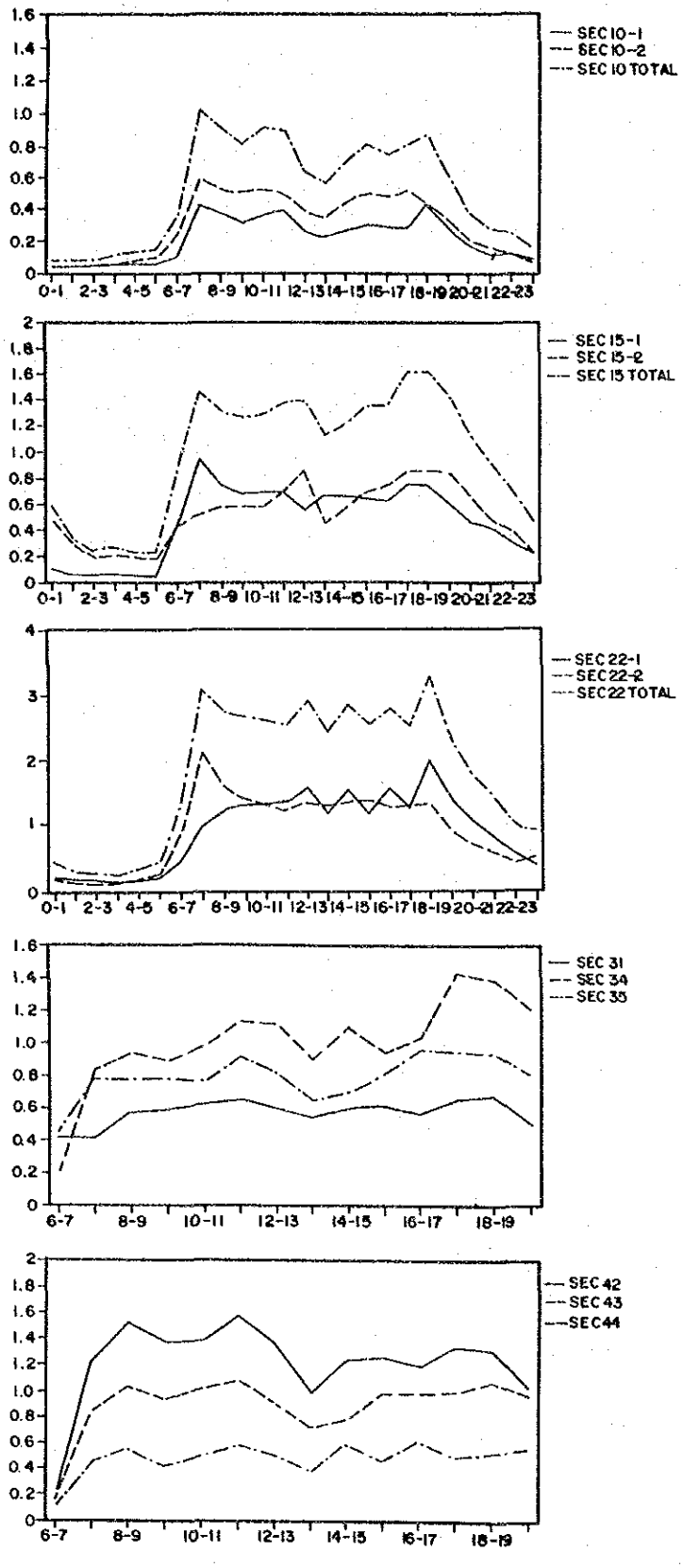

Figure 4.2-1 Hourly Fluctuation of Traffic Volume

4.3 Public Transport

4.3.1 Bus Routes

Nineteen (19) companies operate seventy (70) routes. Additionally several routes operate only on weekends. Routes start from residential area at outskirt of the city, extend to the city center through several trunk roads, and run around the Centro area and then return to starting points through same or adjacent roads. In the central area, bus route network is relatively dense, however in the suburban area it is sparse due to smaller demand and poor road network (refer to Figure 4.3-1(A),(B)).

4.3.2 Demand

Total daily demand counts 1.24 million. Monthly change of demand is generally in the range of 10%. Bus routes are divided into three groups by terminal location at outside end: urban routes, transitional routes and suburban routes. Average number of transported passengers by each route group classified above are 26,266, 27,084 and 14,720 a day, respectively. Bus operating services concentrate on several road sections, especially about 30 bus routes concentrate into Av. Almirante Barroso/Av. Nazare trunk line section due to operating system in which private companies operate bus in view point of demand and supply balance. Therefore, the bus service frequency is close to the limit of capacity of accommodation, and bus transport efficiency is decrease due to long running kilo-meters of buses.

Peak hours are observed at 7:00 hour period in the morning and at 17:00-18:00 hour period in the evening as shown in Figure 4.3-2. No peak hour is observed at noon time.

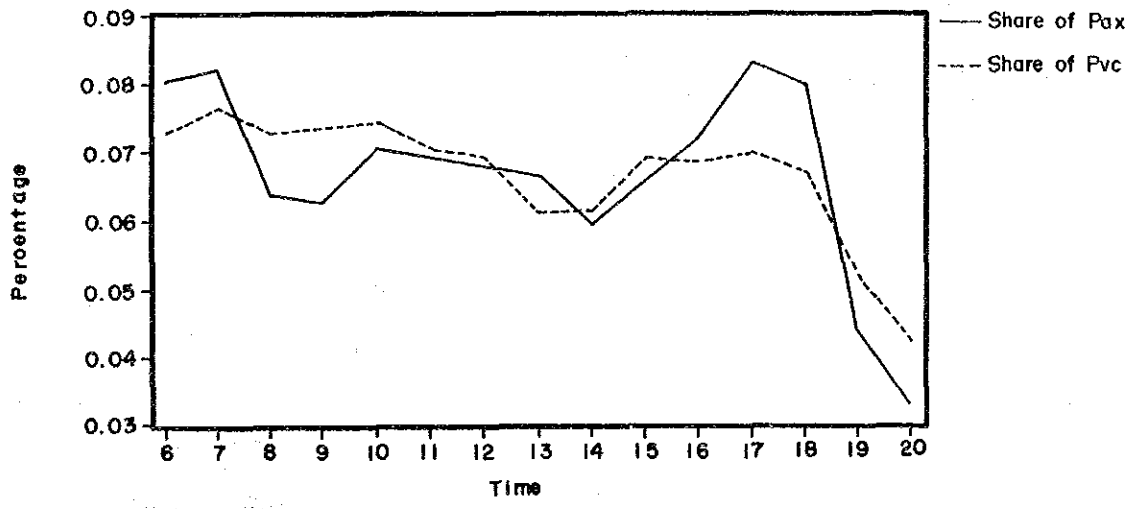

Figure 4.3-2 Hourly Fluctuation of Services and Passengers (March 1990, Both Directions)

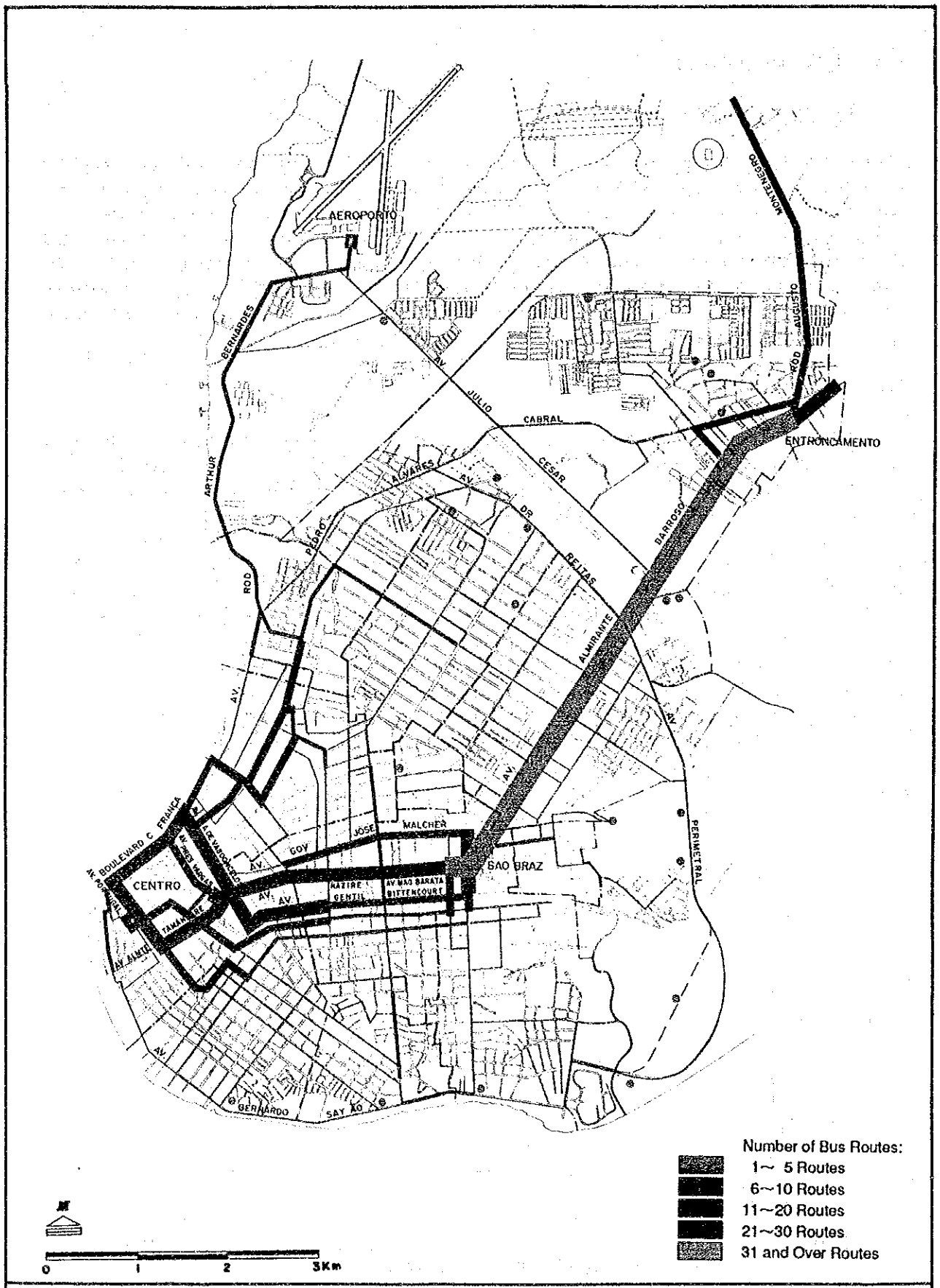

Figure 4.3-1(A) Bus Routes (Urban Area)

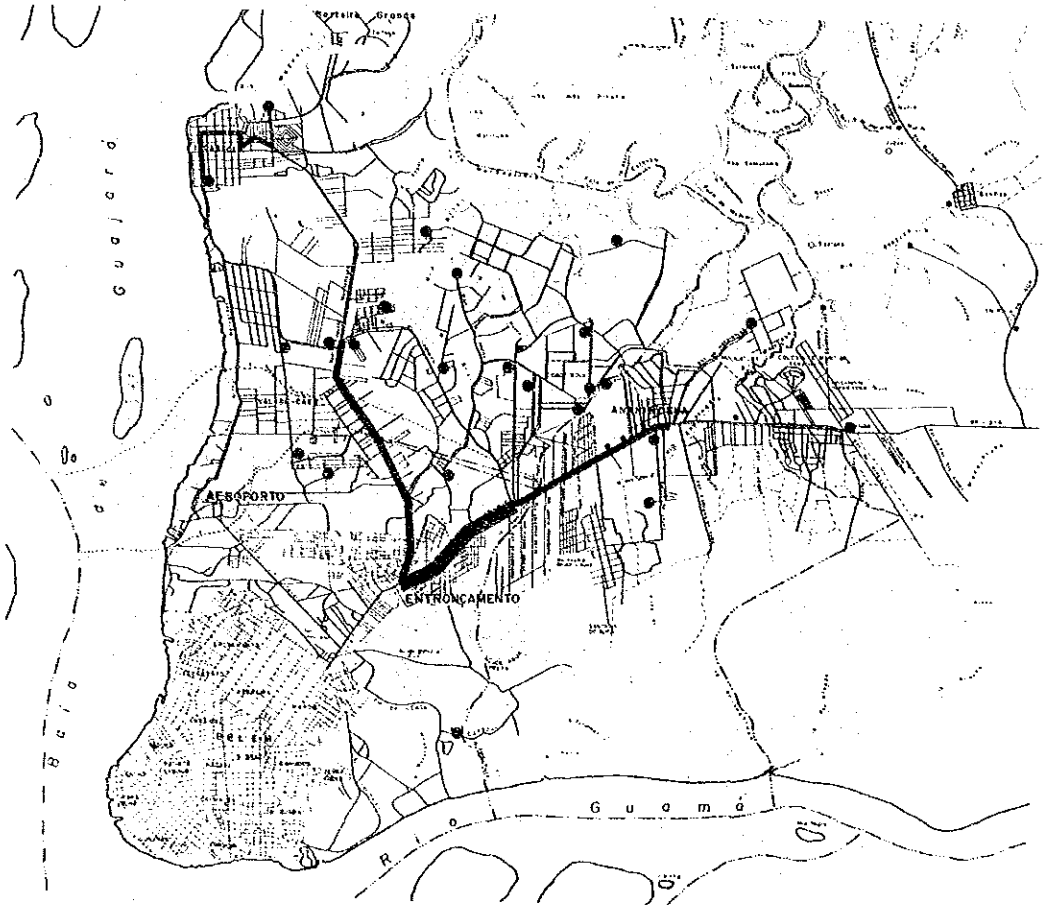

Figure 4.3-1(B) Bus Routes (Suburban Area)

4.3.3 Supply

Nineteen (19) operators exist in BMR at this moment (March 1990). Each operator has a territory at a terminal end of a route where terminal facilities was located. Almost all routes provide transport service from 5:00 a.m. until 11:00 p.m.

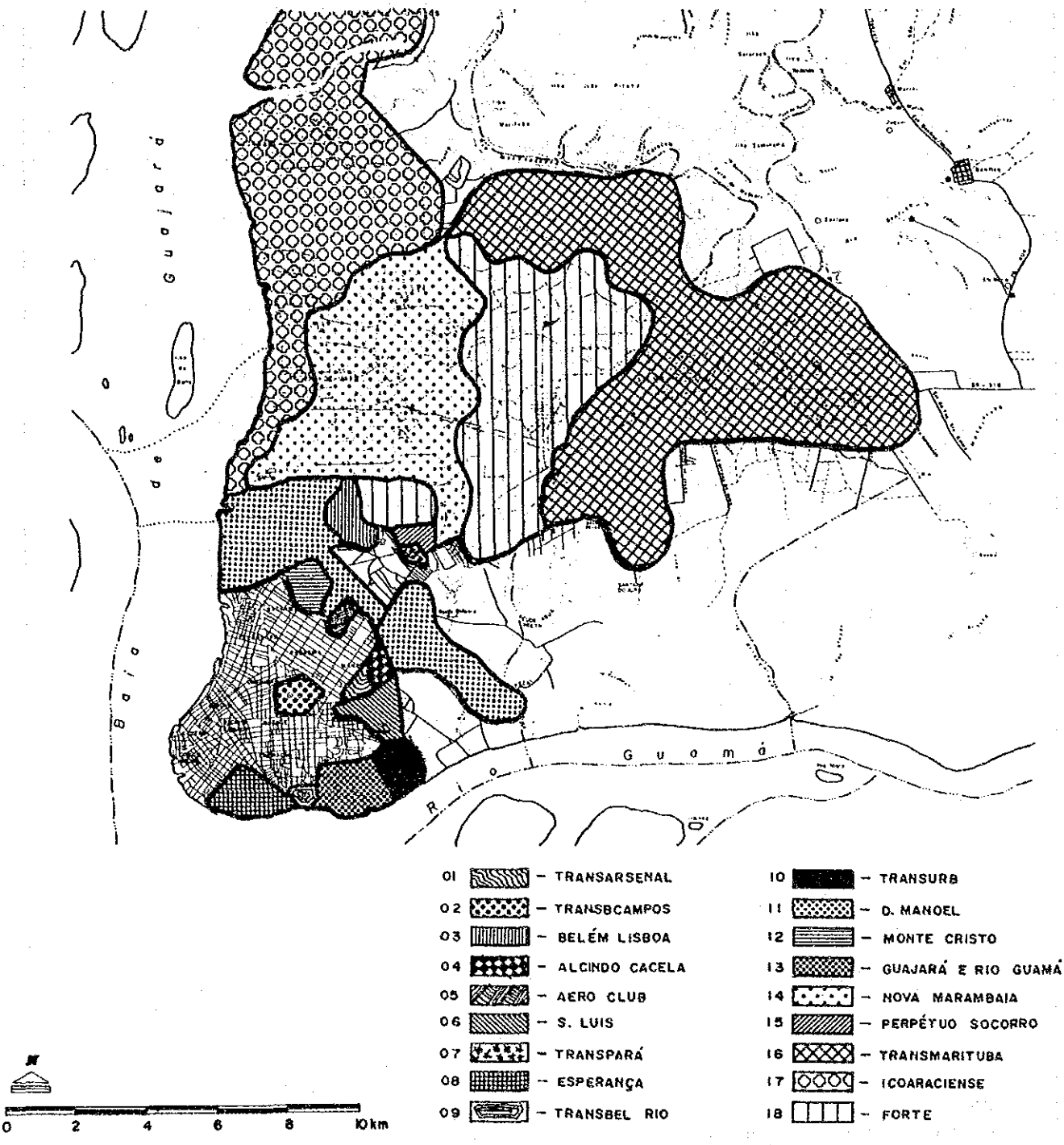

Figure 4.3-3 Territory of the Operators

4.4 Traffic Management System

4.4.1 Traffic Regulations

Traffic regulations in the Study Area are enforced one-way regulation, speed limit, restrictions of vehicle operation and parking restriction. The one-way regulation is enforced on most of the major streets in the central area except on the following roads (refer to Figure 4.4-1):

Av. Alcindo Cacela
Av. Visconde de Souza Franco

The speed limits are regulated by road types: express way 80km/h, artery road 60km/h, distributor 40km/h and local road 20km/h. Heavy vehicles are restricted from operating within Comercio area for the whole day.

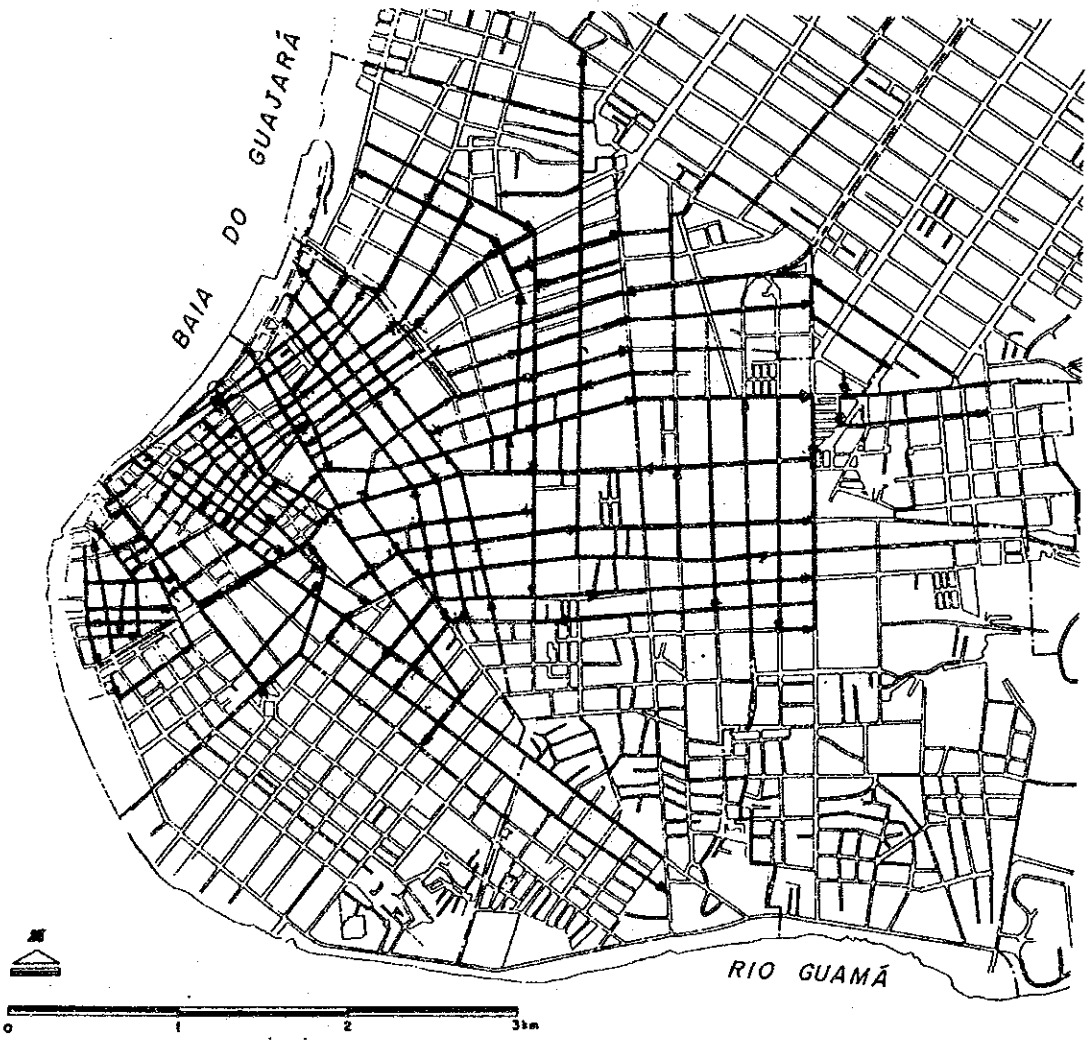

Figure 4.4-1 One Way Regulation, 1990

There are two types of curb parking restrictions in the Study Area. One is the area where every vehicle is prohibited curb parking, and other is the area where only taxi and vehicles for loading/unloading are able to park (refer to Figure 4.4-2).

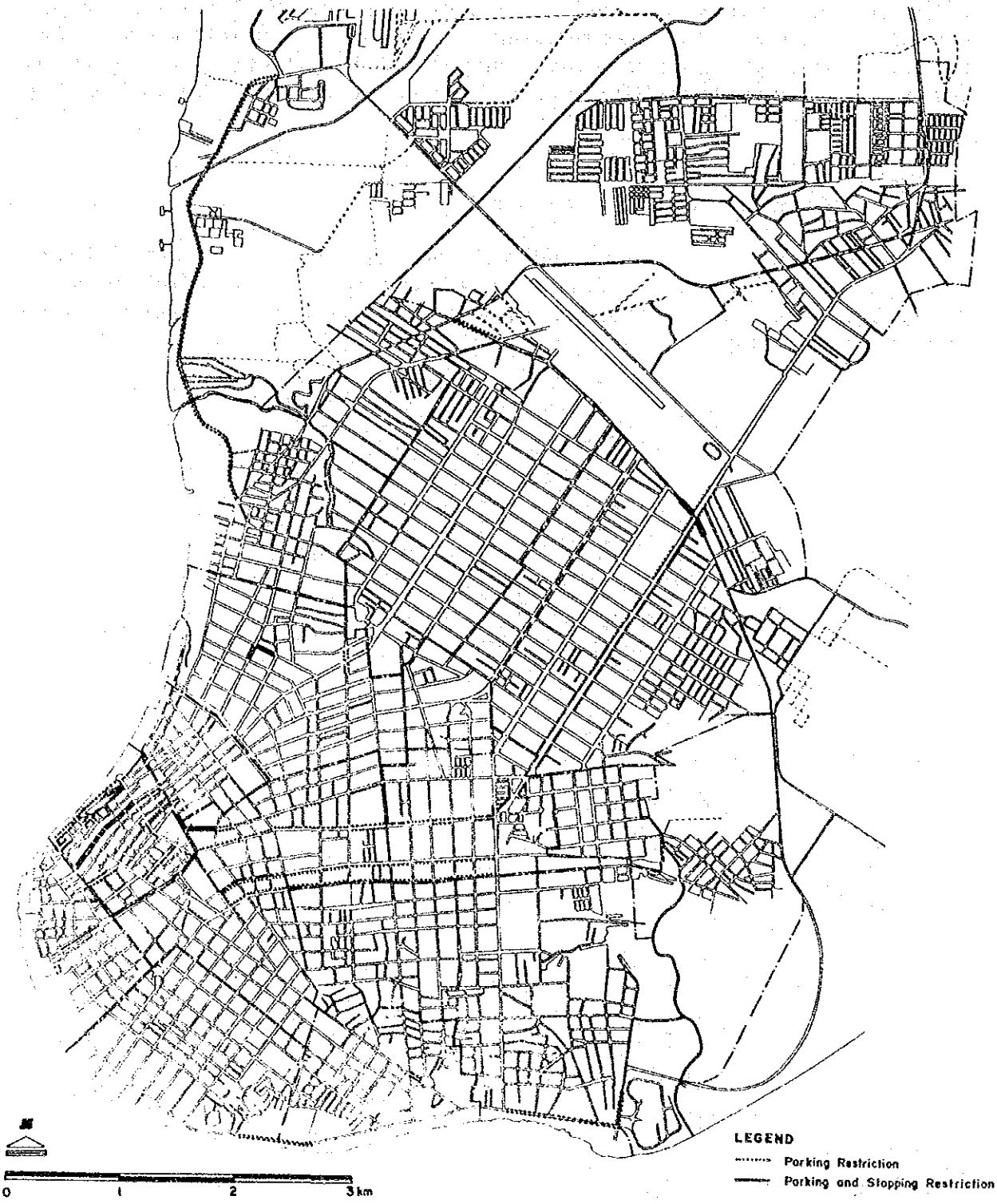

Figure 4.4-2 Parking Restrictions in Urban Area

4.4.2 Signal

There are two types of signal sets, one is traffic control signal and the other is stop signal where a yellow lamp is used as stop sign. There are traffic control signals at 179 intersections and stop signals at 9 intersections in the Study Area. Synchronized control is operated only for seven (7) intersections on Av. President Vargas in Comercio area. The cycle lengths are short at all signalized intersections; the composition rate of cycle length ranged from 30 to 40 seconds in 35% of the total and under 60 seconds for 73% as shown in Figure 4.4-3. It seems necessary to improve those parameters for independent signal control system considering their bad platoon condition.

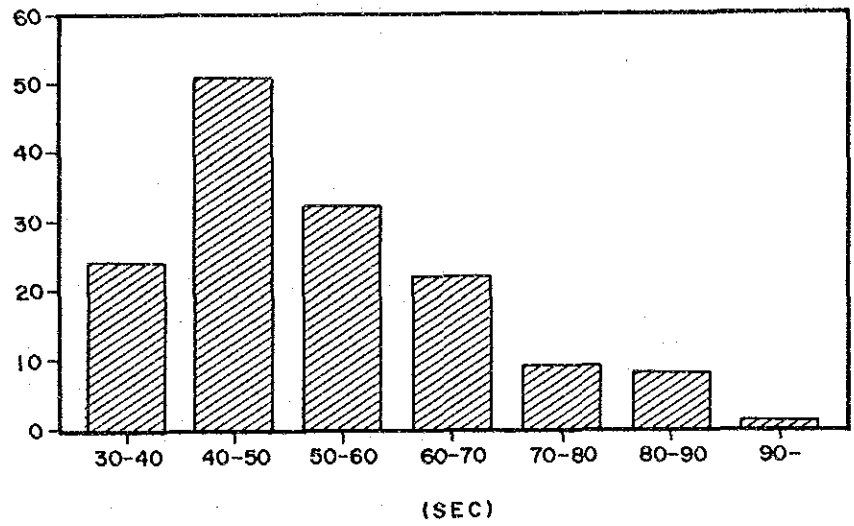

Figure 4.4-3 Distribution of Cycle Length

4.4.3 Parking

There are many parking lots because of high road density in the central area. The capacities of curb parking in Comercio, Batista Campos and Nazare are estimated at approximately 10 thousands lots. On the other hand, off-street parking lots are concentrated in Comercio area. The capacities of off-street parking lots in Comercio, Batista Campos and Nazare are 4,700 lots, about 40% of which are for private use. According to Person Trip Survey, parking demand is estimated as shown in Table 4.4-1.

As for the purpose of parking demand: "to work", "business" and "private", the demand is almost equal. The "to school" purpose demand is only a few. Table 4.4-2 shows the fluctuation of parking density on main streets in Comercio, Batista Campos and Nazare. The parking density in Comercio is high from 0.75 to 1.0 but in other areas, it becomes less than 0.5. The parking densities of the facilities are low exclusive of belonging to offices.

Table 4.4-1 Parking Demand from Person Trip Survey (1990)

Area	To work	Business	To school	Private	Total
Comercio	11,288	10,652	39	8,680	30,659
	(36.9)	(34.7)	(0.1)	(28.3)	(100.0)
Bat. Campos	2,067	3,012	318	3,030	8,427
	(24.5)	(35.7)	(3.8)	(36.0)	(100.0)
Nazare	6,153	5,460	684	10,402	22,699
	(27.1)	(24.1)	(3.0)	(45.8)	(100.0)
Total	19,508	19,124	1,041	22,112	61,785
	(31.6)	(31.0)	(1.7)	(35.7)	(100.0)

Note: Composition Ratio in Parentheses

Table 4.4-2 Parking Density on Main Street

Area	10:00	12:00	14:00	16:00	18:00
Comercio	0.90	0.78	0.80	1.00	0.75
Bat. Campos	0.37	0.38	0.30	0.41	0.43
Nazare	0.46	0.36	0.35	0.41	0.45
Total	0.50	0.43	0.40	0.49	0.48

Note; Parking density = parking veh./capacity

5. PRESENT PERSON TRIP CHARACTERISTICS

5.1 Outline of Person Trip Survey

Person Trip Survey was conducted through home interviews in which interviewers directly visited homes in the Study Area to obtain information on travel characteristics.

The survey was carried out during March to April, 1990. A random sample of 21,000 households, equivalent to a sample rate of 7.2% of total population (6 years old or above), was collected from the Study Area which was divided into 64 traffic zones. The collected information was as follows; social indicators (age, sex, occupation,etc.), economic indicators (total number of families, vehicle ownership, monthly income, etc.) and trip information (origin, destination, purpose, departure time, etc.).

5.2 Total Number of Trips

The total number of trips per day in the Study Area in 1990 is approximately 2.89 millions, of which 2.87 million trips are made by residents in the Study Area, and the other by non-residents who are not dwelling in the Study Area.

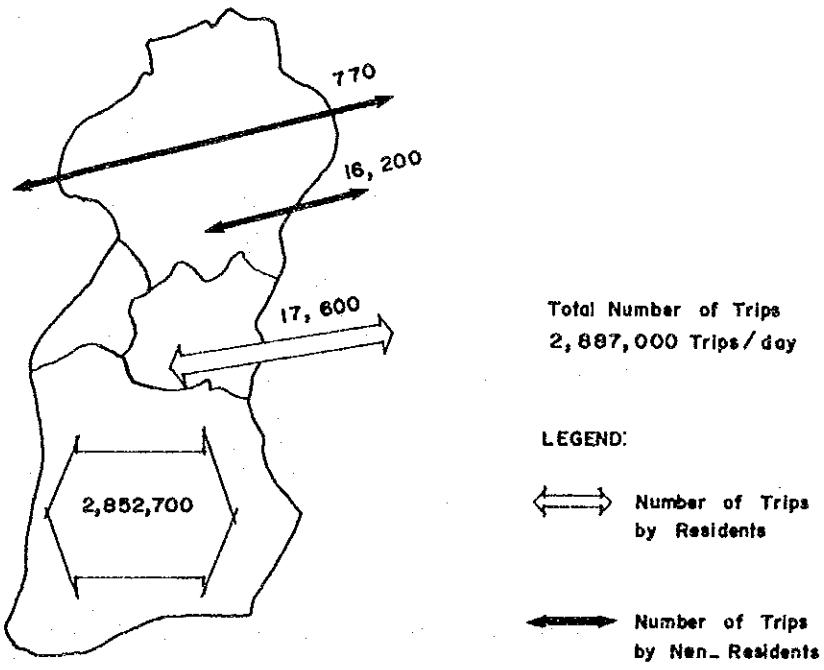

Figure 5-1 Total Number of Trips in the Study Area

As seen from Figure 5-2 which shows the trip purpose made by all modes, the composition of "to home" trip purpose is highest (41%), followed by 21% for "private/others", 18% for "to work", 15% for "to school" and 5% for "business".

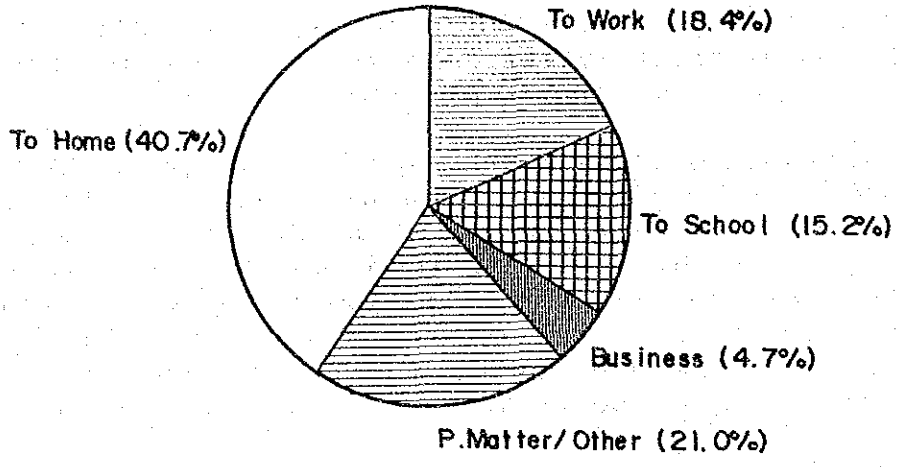

Figure 5-2 Composition of Trip Purposes (All Mode)

As for trip composition by mode, bus mode accounts for nearly a half of all mode. In case of trip composition excluding walking mode, bus transport rises at 76% of all mode.

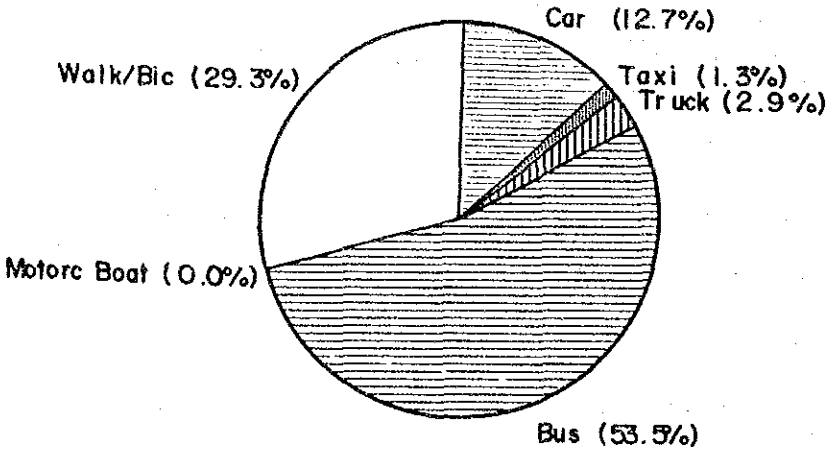

Figure 5-3 Composition of Modes (All Purpose)

The trip production rate is 2.25 per day, of which 2.66 is for male, and 1.90 for female. The age groups with higher trip production are the aged 25-59 years old group of male and 20-44 years old of female.

Trip generation and attraction by trip purpose according to the integrated zone are shown in Figure 5-4 and 5-5. The zones with large numbers of generation and attraction are of the central area due to concentration of business activity center of BMR to those zones.

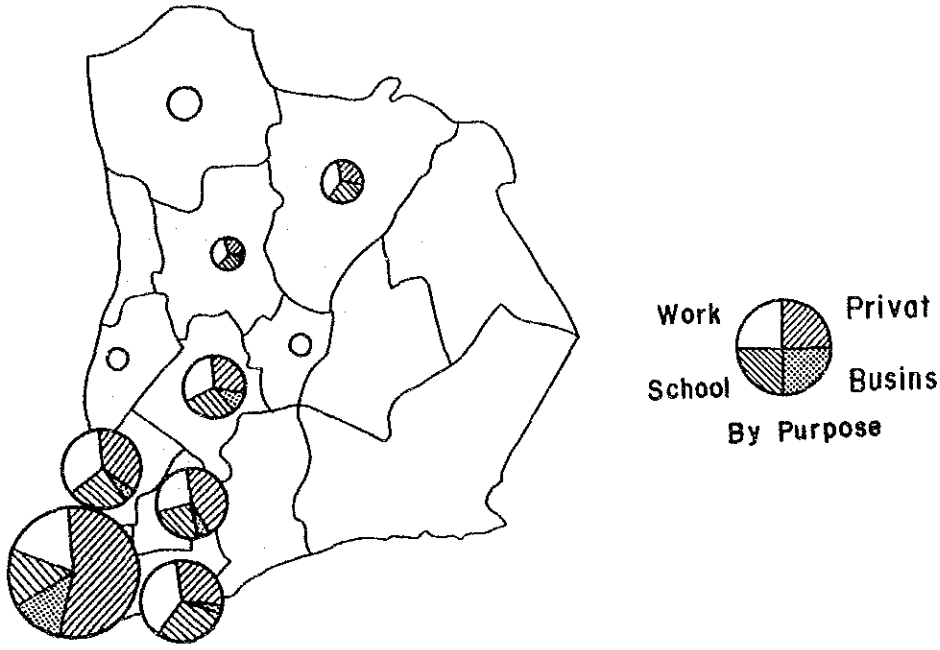

Figure 5-4 Trip Generation (1990)

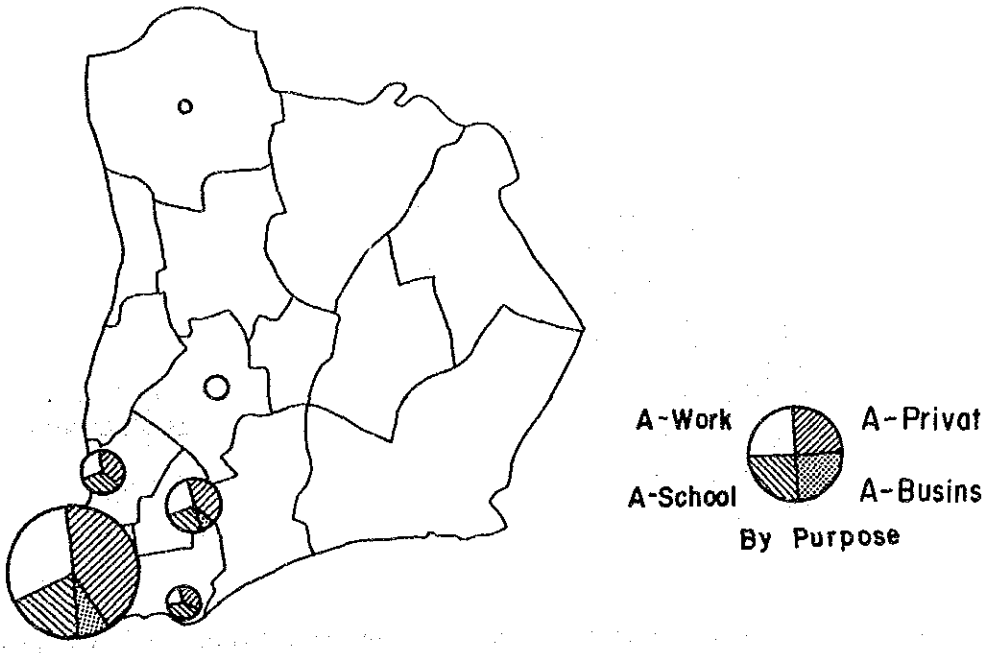

Figure 5-5 Trip Attraction (1990)

Trip distribution by all modes and purpose is shown in Figure 5-6 by desire line charts. There are large movements within the central area and between this area and its surrounding suburban area. The trip movement between the suburban area is meager. This seems to indicate that the commercial and business activity centers, and opportunity of employment concentrate in the central area.

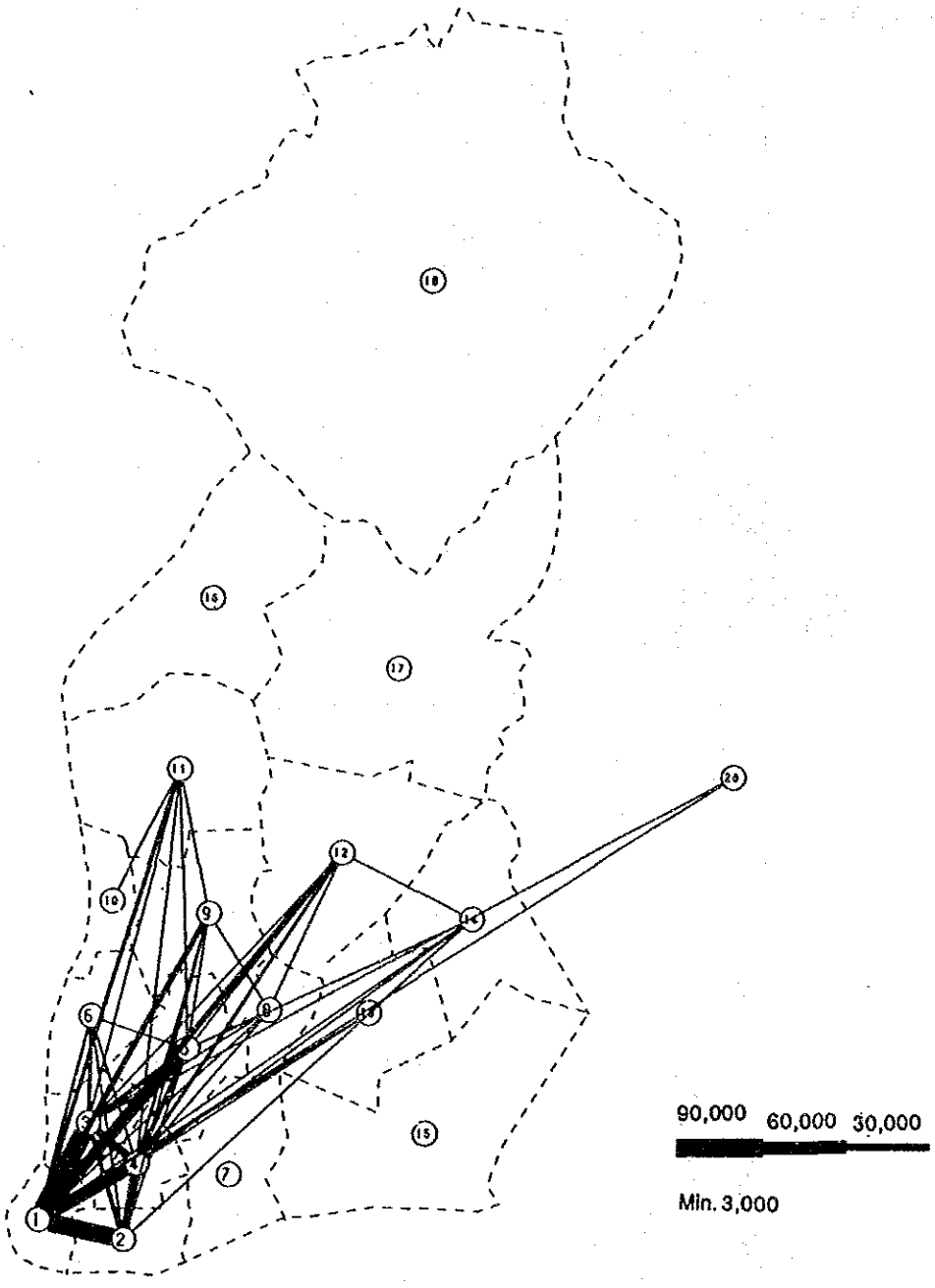

Figure 5-6 Trip Distribution by All Mode and Purpose

6. SOCIOECONOMIC FRAMEWORK AND LAND USE PLAN

6.1 Socioeconomic Framework

(1) Future Economic Growth

Assumption of economic growth rate of Brazil and Para State will be remain at low level for a period of 1990 and 1995, and after this period, the economic growth will be accelerated upward. A target growth rate is set up for each period as shown in Table 6.1-1.

Table 6.1-1 Future Economic Growth Rate of Brazil and Para (%)

Period	Brazil	Para
1990-1995	2.3-2.5	5.0
1996-2000	5.0-6.0	9.0
2001-2010	6.0-7.0	8.5

The future economic growth of the Study Area is assumed to be lower than that of Para and higher than that of Brazil, based on the past trend and the future prospect of the Area (Table 6.1-2).

Table 6.1-2 Future Sector Growth Rate of the Study Area's GRP (%)

Sector	1990-1995	1996-2000	2001-2010
Primary	-2.0	-2.0	-2.2
Secondary	2.9	5.9	4.7
Tertiary	4.4	8.2	7.4
Total	4.0	7.6	6.8

(2) Population

Future population was estimated by dividing into two portions: natural increase part and in-migration part. The natural increase rate in the Study Area is declining at a considerably rapid pace, and is estimated to have become lower than the national average in 1989/1990. However, it is difficult to consider that this rapid decline will continue for a long time and that the natural increase rate of the Study Area will go down to a level far below the national average.

On the other hand, the future net in-migration rate is depends on which Belem will continue to attract people as the capital city of Para, or not. Though the huge development of Amazon basin is not able to expect in future, Belem will continue to attract people as a great core of the tertiary sector activities. The assumed population increase rate is shown in Table 6.1-3.

Table 6.1-3 Population Increase Rate (%, thousand)

	1990	1995	2000	2010
Natural Increase Rate		1.75	1.63	1.57
Social Increase Rate		1.35	1.17	0.92
Future Population	1,149	1,562	1,897	2,425

The future labor force demand in the Study Area and its vicinity is forecasted as shown in Table 6.1-4, based on the assumed future economic growth rate and population increase rate.

Table 6.1-4 Total Future Labor Force Demand in the Study Area and Its Vicinity (thousand)

	1990	1995	2000	2010
Labor Force	541	682	863	1,266
Employment				
Primary Sector	7	6	6	4
Secondary Sector	80	95	118	159
Tertiary Sector	407	498	688	1,060
Total	494	599	812	1,233
Unemployment (%)	8.7	12.2	5.9	3.4

(3) Income

From Table 6.1-5, it can be expected that the future average household income will be doubled in 2010 in comparison with in 1990.

Table 6.1-5 Projection of GRP per Capita

	1990	1995	2000	2010
GRP (US$ 1,000)	3,553,218	4,320,072	6,229,132	12,026,522
Population (1,000)	1,419	1,652	1,897	2,425
Per capita (US$/p)	2,504	2,615	3,284	4,959
Growth Ratio (1990=1)	1.00	1.04	1.31	1.98

(4) Vehicle Ownership

The future vehicle ownership of the Study Area is forecasted to stay at a relatively lower level than that of other city of Brazil due to structure of income distribution and high price of vehicle. The future number of vehicles in 2010 is estimated about double of present figure as shown in Table 6.1-6.

Table 6.1-6 Future Car Ownership

year	Pass.Car	Truck	M/Cycle	Bus	Total	Rate/1000 Persons
1989	76,431	13,950	6,142	1,981	98,504	71.2
1995	105,562	16,788	7,750	2,511	128,611	77.9
2000	121,198	19,239	9,958	2,847	153,242	80.8
2005	139,308	21,437	10,090	3,158	174,029	80.8
2010	156,128	23,579	11,080	3,439	194,226	80.1

6.2 Land Use Plan

The increase of resident population is assumed approximately 1 million persons during the coming 20 years. Population growth of the Study Area is mostly allocated in the suburban area and is controlled in the central area to maintain the good conditions for urban environment. The new urban center system is introduced for the purpose of decentralization of urban center. Urban sub-centers in Entrocamento, Icoaraci and Ananindeua will enlarge their population size and economic activities to produce employment opportunities for workers. Table 6.2-1 shows the allocation of the population, enrollment, employment, etc. in the target year of 2010 by zone. Figure 6.2-1 shows the future land use plan.

Table 6.2-1 Allocation of Future Socioeconomic Indices

Int. Zone	Population (2010)	Employment(2010) Home Base	Primary	Secondary	Tertiary	Enrollment(2010) Home B.	School B.
Centro	156,510	85,390	710	28,830	217,720	19,310	60,720
Guama	238,190	122,810	140	11,630	91,050	20,760	21,710
Sacramenta	235,340	123,190	120	15,530	150,740	22,980	23,260
Marco	145,960	79,020	180	15,440	156,270	16,830	28,370
Marambaia	169,360	88,250	100	7,680	51,040	16,750	12,180
Aeroporto	74,290	37,680	20	3,340	20,390	3,830	1,830
Embrapa	350	140	120	980	5,220	50	710
Guanaba	104,140	50,640	60	4,950	33,740	7,170	3,330
Bengui	303,550	156,170	40	8,320	56,670	22,720	7,770
Pratinha	73,750	32,210	620	7,300	28,160	4,150	790
Icoaraci	150,280	82,860	930	20,640	46,850	6,330	4,230
Cidade Nava	350,600	170,190	90	7,990	55,960	23,550	6,720
J. Seffer	168,560	77,110	20	4,660	27,150	11,520	4,160
Ananindeua	231,620	106,160	120	33,400	71,690	12,600	12,600
Aura	500	150	10	20	190	30	0
Outeiro	6,500	3,640	20	1,040	4,890	200	40
Ilhas	0	0	10	0	0	0	0
Mosqueiro	15,500	7,390	90	920	8,270	1,220	1,520
Exterior	0	0	600	4,330	16,000	0	60
Total	2,425,000	1,223,000	4,000	177,000	1,042,000	190,000	190,000

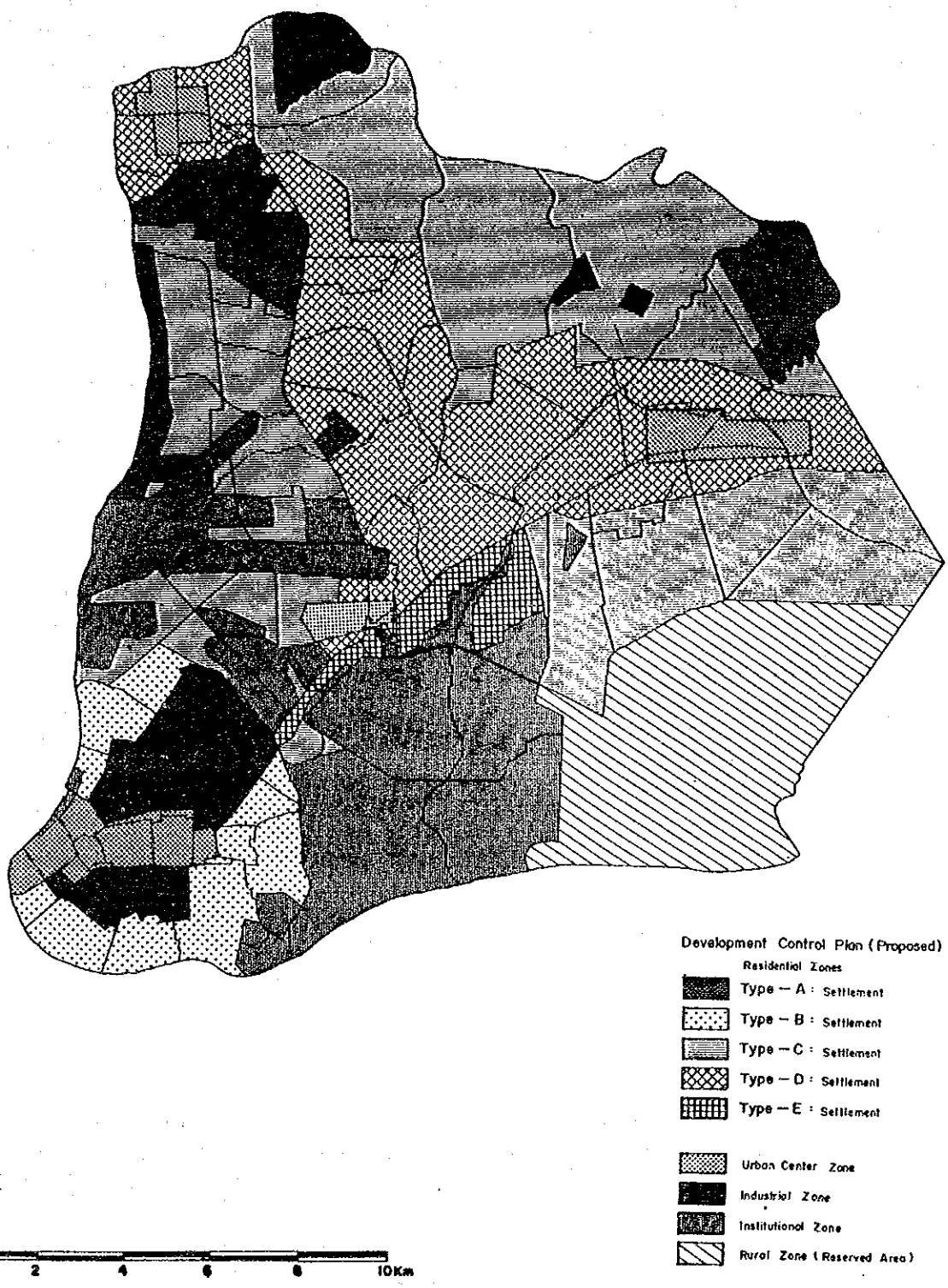

Figure 6.2-1 Future Land Use Plan

7. FUTURE TRAVEL DEMAND

7.1 Travel Demand Model

The urban travel demand model commonly known as the "Four Step Model" was employed in the Study. The four step method is used to predict (1) the number of trips made within the Study Area, (2) zonal origin-destination (OD) pair, (3) the mode of travel used to make these trips, and (4) the routes taken through the transportation network. The flowchart of forecasting model is shown in Figure 7.1-1.

7.2 Projection of Travel Demand

(1) Total Number of Trips

The total number of trips per day in the Study Area in 20101 is approximately 5.13 millions, of which 5.03 million trips are within the Study Area, and the other is for trips which has the trip origin or destination in the outside of the Study Area.

Table 7.2-1 Summary of Socioeconomic and Travel Demand (1990/2010)

Indicators	1990	2010	2010/1990
1. Population	1,419,224	2,425,000	1.71
2. GRP Growth Rate per Capita (1990 = 1)	1.00	1.98	1.98
3. No. of Car Operated	76,431	156,128	2.04
4. No. of Motorized Households			
1) Non-Motorized	246,397	397,571	1.61
2) Motorized	56,044	119,204	2.13
Ratio (/1000)	185	231	
3) Total	302,441	516,775	1.71
5. Daily Trips			
1) No. of Trips per Person	2.25	2.28	1.02
2) Total Daily Trips	2,887,458	5,125,877	1.78

As for the future composition of trip purpose, "private" purpose ratio is highest (20.6%) exclusive of "to home" (40.3%), followed by 18.6% for "to work", 15.0% for "to school" and 5.5% for "business".

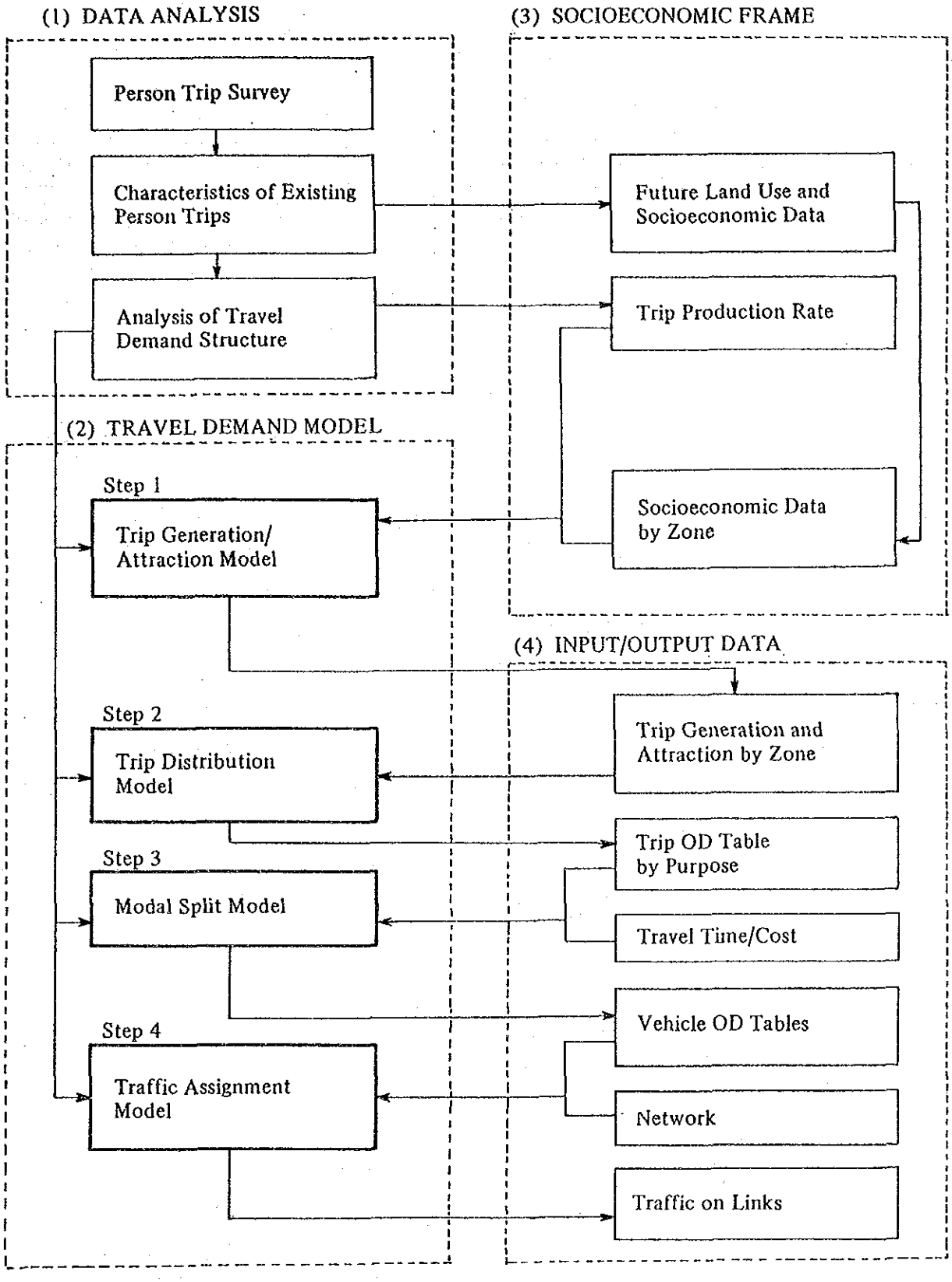

Figure 7.1-1 Flowchart of Forecasting Model

(2) Trip Generation and Attraction

Estimated trip generation and attraction in the year 2010 according to the integrated zone are shown in Figure 7.2-1 which shows comparison between the figures in 1990 and 2010. The central zones are still large in the trip generation and attraction. The increase rate of trip generation between 1990 and 2010 in the suburban area becomes dramatically high (2.0-5.0), which central area is somewhat high (1.2-1.8).

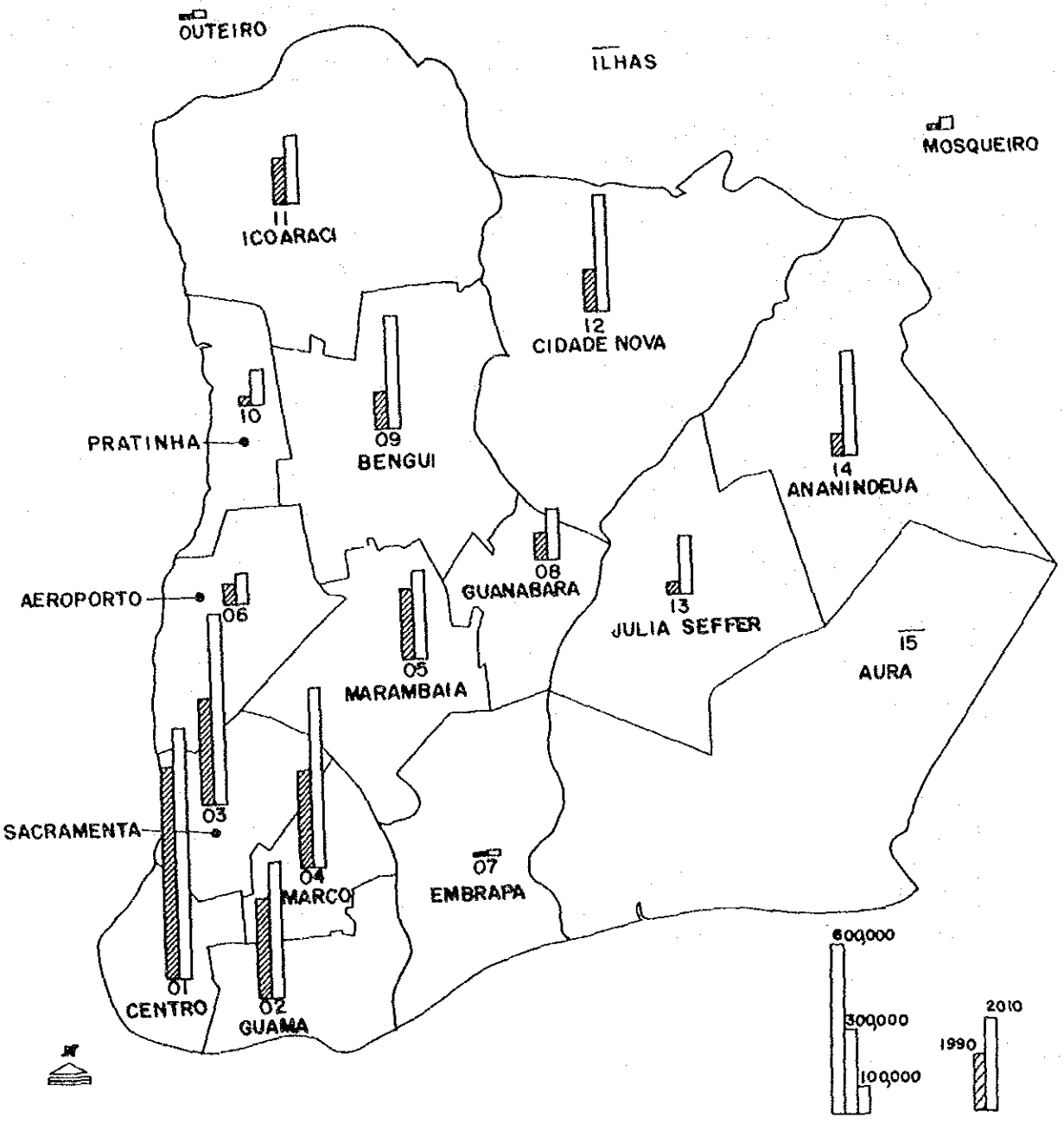

Figure 7.2-1(A) Trip Generation (1990/2010)

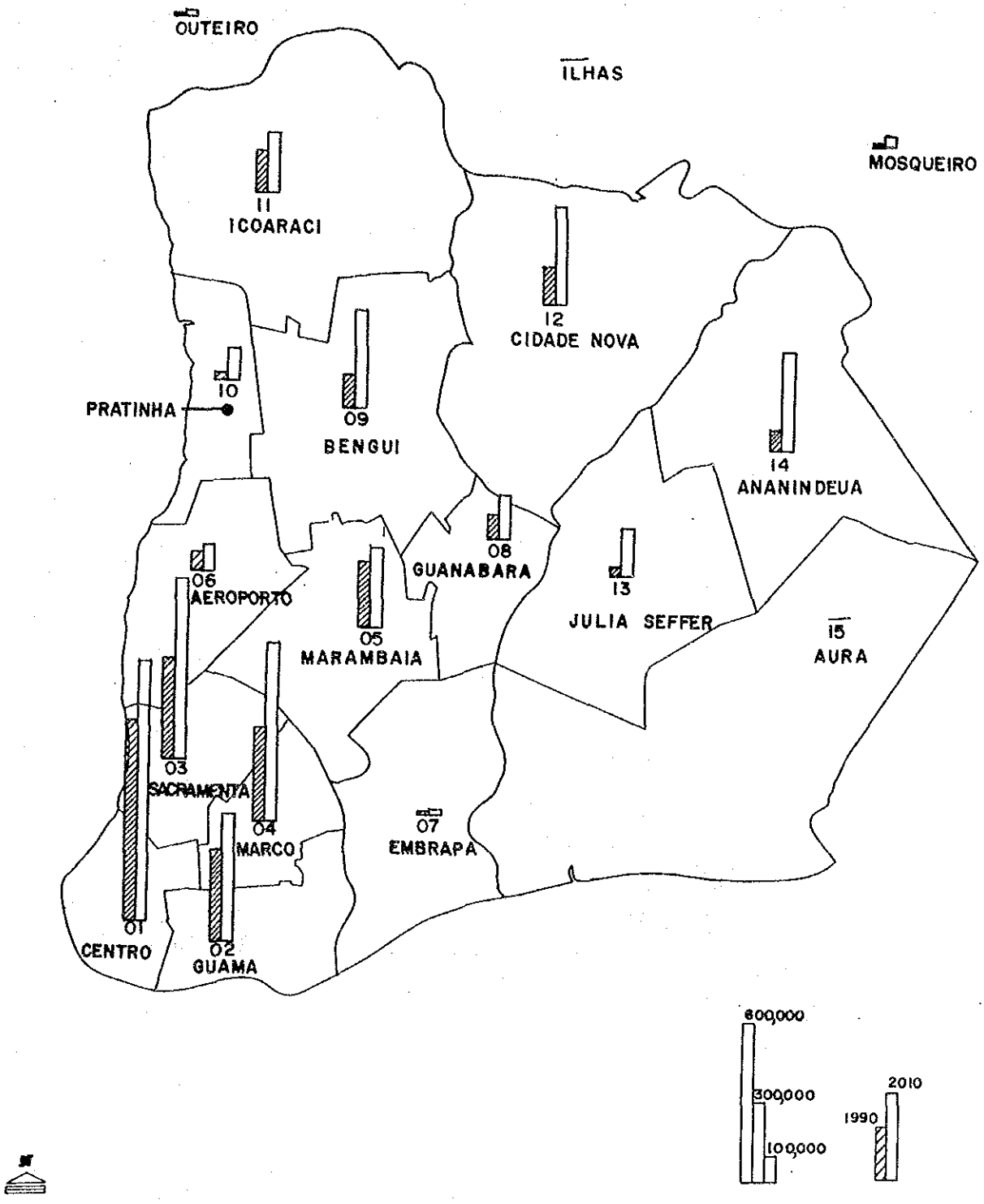

Figure 7.2-1(B) Trip Attraction (1990/2010)

(3) Trip Distribution

Figure 7.2-2 illustrates the desire lines for interzonal trips in 2010. Comparing to strong desire lines in 1990 which is predominantly within the central area, OD trips in 2010 linked between the central and suburban areas are considerably higher.

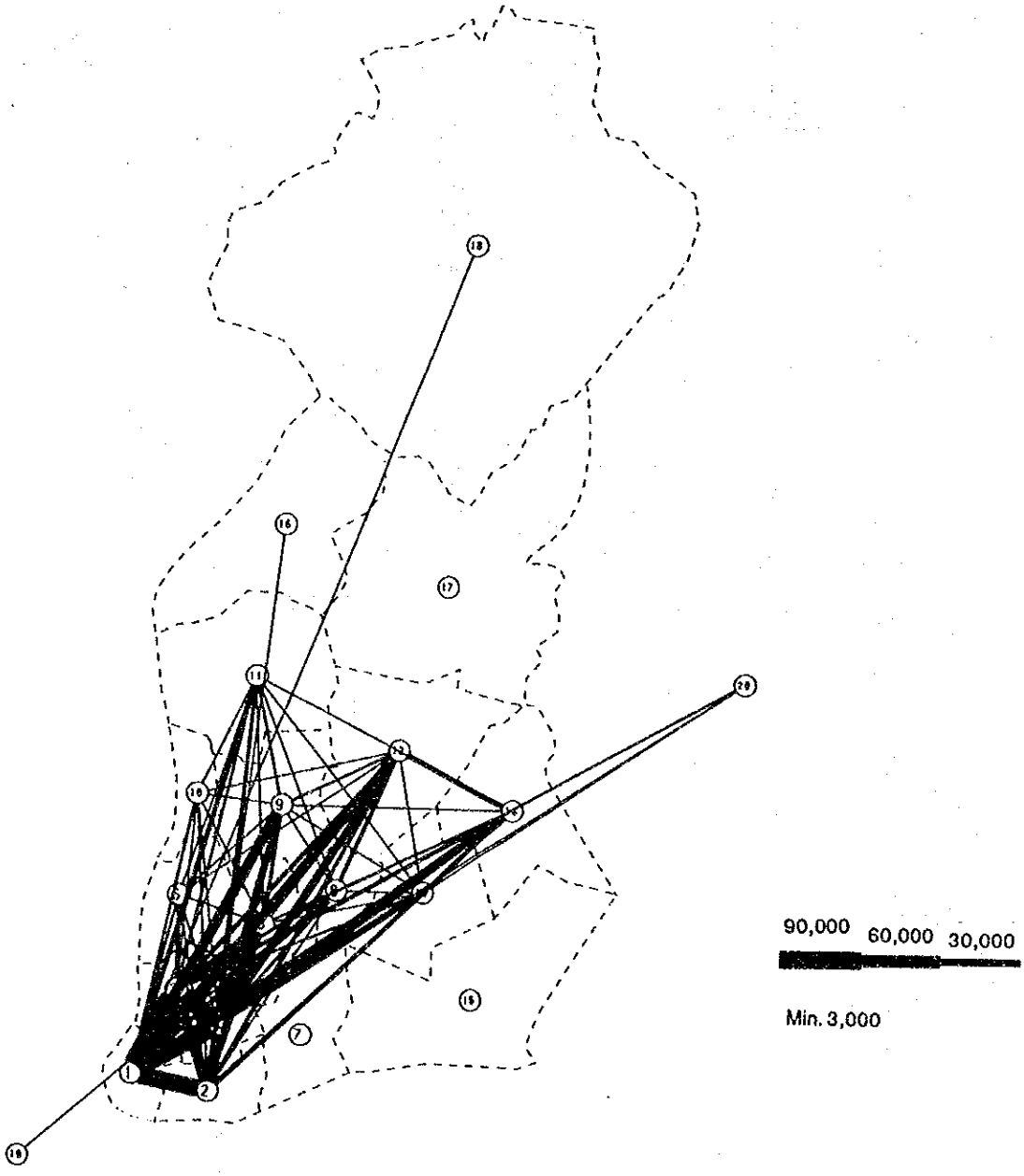

Figure 7.2-2 Trip Desire Lines (2010)

(4) Modal Split

Number of trips by mode which is classified into 3 modes, Walking, Public and Private Transport, is shown in Table 7.2-2. The modal share of public transport raises by 62% due to decrease of car ownership and development of residential area to suburban area.

Table 7.2-2 Modal Share of Person Trips (unit:person/day)

Mode	1990		2010		2010/1990
	No. of Trip	Comp.	No. of Trip	Comp.	
Walking	851,016	0.29	1,043,558	0.20	1.23
Public	1,544,975	0.54	3,166,034	0.62	2.05
Private	491,467	0.17	916,285	0.18	1.86
Total	2,887,458	1.00	5,125,877	1.00	1.78

(5) Traffic Assignment

Traffic assignment on the present road network was made to disclose traffic demand on major corridors. Figure 7.2-3 shows the assignment result. The heavy traffic flows are observed in both corridors: Av. Almirante Barroso/BR-316 and Rd. Arthur Bernardes which connects between central and suburban area where future development will be planned. The future demand of those corridors will exceeds its capacity due to few roads running through Institutional belt.

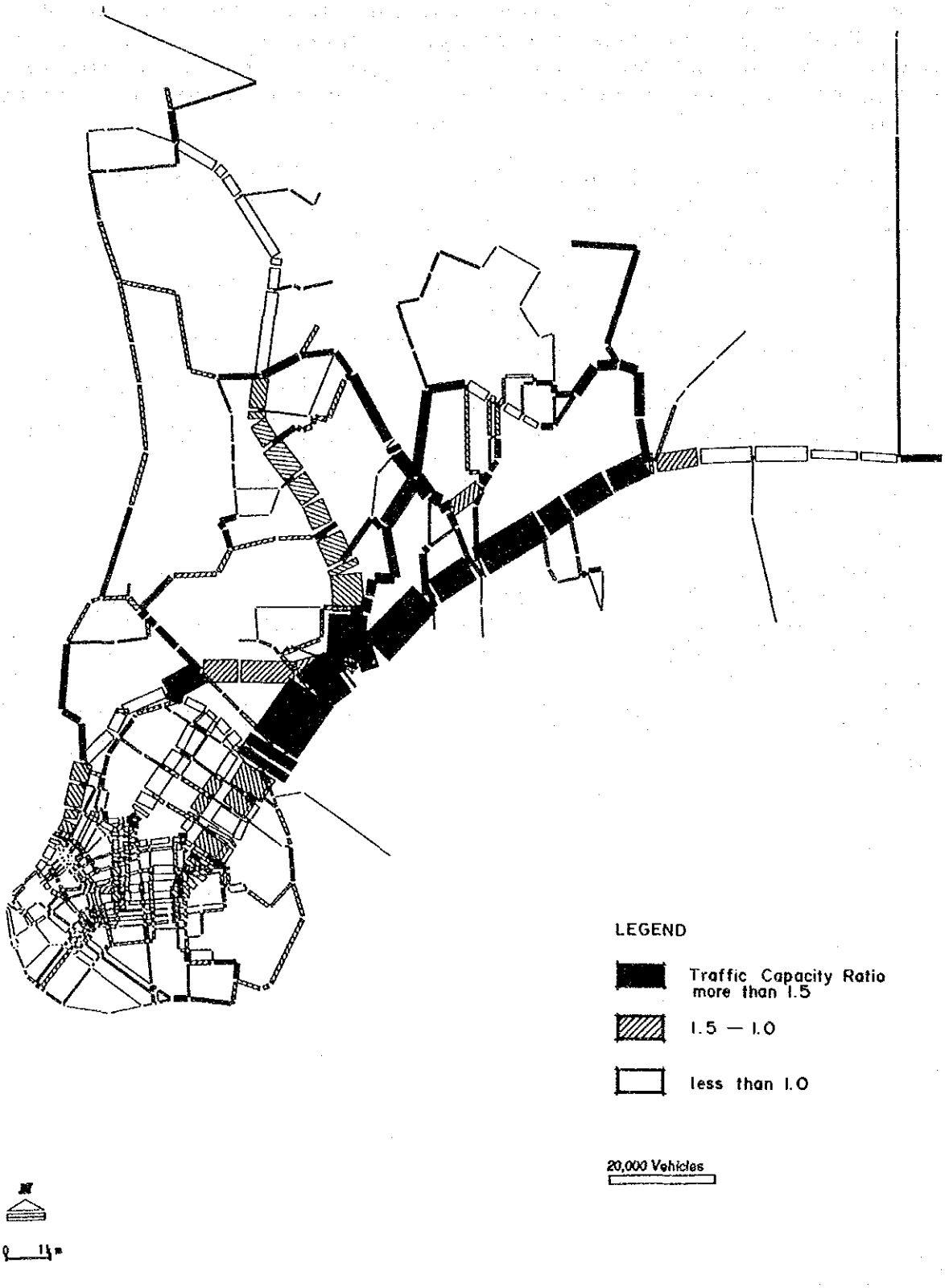

Figure 7.2-3 Future Traffic Flow (2010) on the Present Road Network

8. BASIC TRANSPORT POLICIES

8.1 Present Issue

As explained in the previous chapters, the present traffic flow on existing road network has few of the problems usually faced by major arterials and distributors. Taking into account the future population growth during 20 years, extension of urbanized area to suburban area and the growth of vehicle ownership, the major improvement target of the transport network are as follows;

1) strengthening of the capacity of road network between the central and suburban area,
2) strengthening of the capacity of public transport network between the central and suburban area,
3) construction of the road network in suburban area, and
4) strengthening of traffic control and management in the central area.

The demand/capacity balance in three major roads running through Institutional belt between 1990 and 2010 is compared in Table 8.1-1. The future demand will exceed the present road capacity which is sufficient for present demand. Table 8.1-2 also shows the comparison of public transport demand and capacity between the central area and suburban area. The public transport demand will exceed the capacity before the year of 2000, if no improvement will be made to the public transport between the two areas.

Table 8.1-1 Comparison of Road Traffic Demand and Capacity

Year	Demand(pcu)	Capacity(pcu)
1990	117,000	156,000
2010	261,000	156,000

note: Traffic demand are those between the suburban area and the central area. Traffic capacity are the sum of those of Av.Almirante Barroso(8 lanes), Av. Pedro Cabral (4 lanes) and Rd. Arthur Bernardes (2 lanes).

Table 8.1-2 Comparison of Public Transport Demand and Capacity

Year	Demand(thousand persons) per day	peak hour	Capacity(thousand persons) peak hour
1990	376	21	29
2000	679	38	29
2010	931	52	29

note: Demand and capacity are estimated at section of Entroncamento on BR-316.)
Capacity of current bus operation is assumed as follows: operation head; 10 seconds (3 berths at each bus stop) average passenger occupancy; 80 persons

8.2 Basic Policies

(1) Road Network Planning

Basic policies for road network planning are classified into two improvement plans: improvement of arterial road network and of the distributor road network in suburban area (refer to Figure 8.1-1). The improvement of arterial road network for strengthening the corridor between the central and suburban areas is as follows.

1) Extension of 1o de Dezembro
2) Improvement of capacity of BR-316/Av.Almirante Barroso
3) Central penetration highway between Cidade Nova and Ver-o-Peso
4) Construction of Val-de Cans Bypass
5) Extension of Av. Pedro Miranda and connection with 2)

In addition to the above plans, the arterial road between Icoaraci and Ananindeua in connection with Para State highway No.-150 (PA-150) is constructed.

As for the distributor road network, the distributor of 2-3 km interval mesh is to be formulated to establish the transport service network.

(2) Public Transport Network

Basic policies for improvement of public transport are to strengthen the capacity of the public transport in major directions between the central and suburban areas. Existing public bus system of the individual route operation in Belem operates every bus from terminal by round trip on specific route. There-

fore, it is foreseen that the operation in the particular road sections will be maintained due to the excess demand for the capacity of bus stop in future.

It is difficult to introduce mass transit system such as the heavy railway system for the improvement and strength of the public bus transport from socioeconomic view point under the economic conditions in Brazil. Therefore, the improvement and strengthening of the existing public bus transport as basic policy is employed in this Study.

1) Introduction of trunk bus operation system
2) Introduction of zone bus operation system
3) Introduction of para-transit system

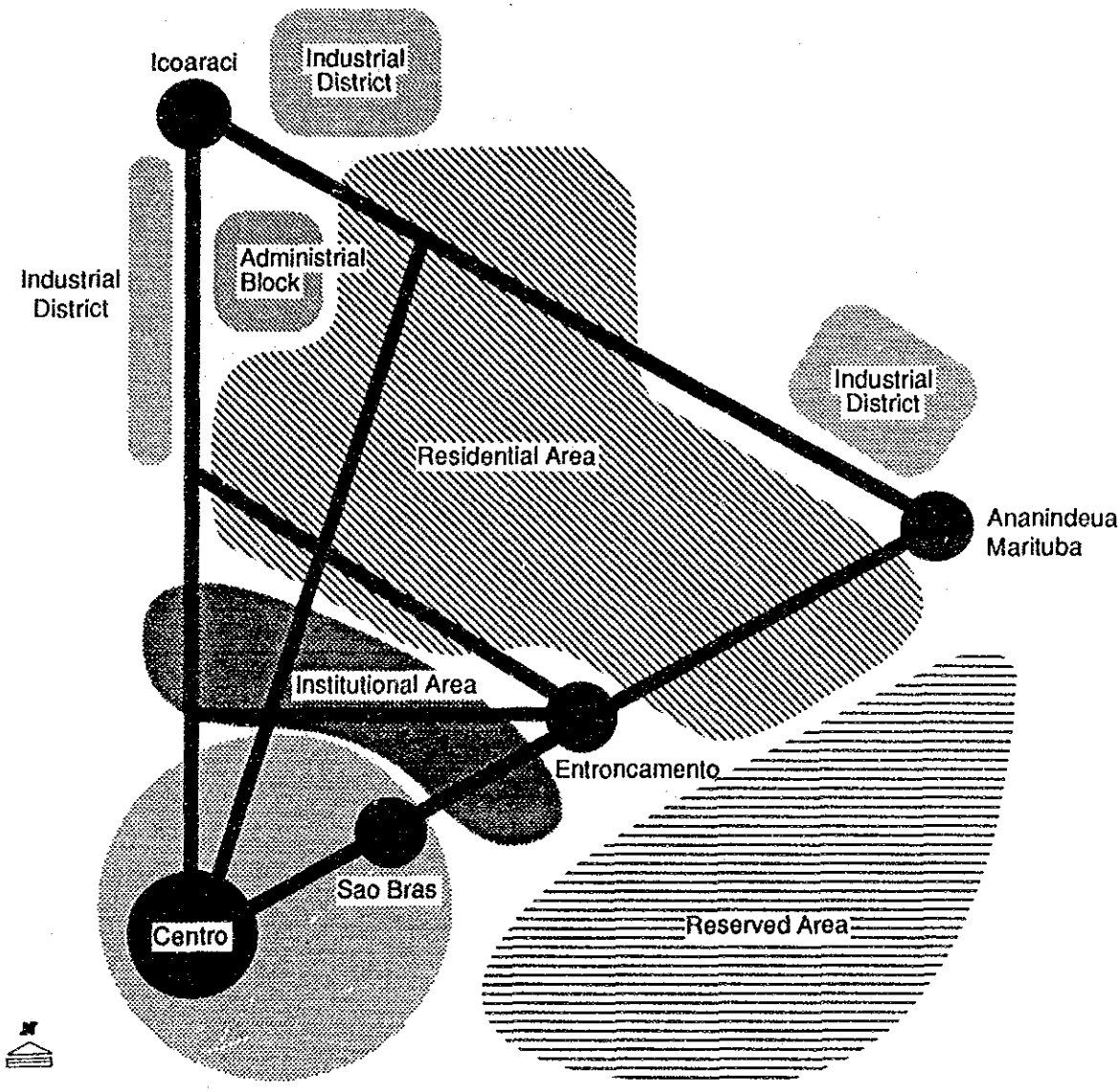

Figure 8.1-1 Future Arterial Road Network Diagram

(3) Traffic Control and Management

Basic policies for the traffic management is to effectively use the existing traffic facilities. It is indispensable to make the improvement plans to ensure smooth traffic flow at present and in the future in the central area where the road network density is sufficient. The following is basic plan of the improvement of the traffic control and management;

1) Classification of road hierarchy
2) Improvement of traffic signal system
3) Improvement of intersection
4) Investigation of parking regulation
5) Establishment of bus priority road

9. ROAD NETWORK PLANNING

9.1 Road Projects

The following 21 projects are selected from the above mentioned planning policy. Figure 9.1-1 shows the project location.

1) Av. Pedero A. Cabral (R01)
   - improvement of unpaved section until 1990
2) Av. 1o de Dezembro Extension (R02)
   - new construction road strengthening this corridor (22.3km)
3) Rodvia Belem (R03)
   - new construction road connecting between the central area and the suburban area (16.5km)
4) Val-de Cans Bypass (R04)
   - new construction road to link between Av.A.Montenegro and Ver-o-Peso (6.3km)
5) Av. A. Barroso (R05)
   - exclusive bus lane (6.1km)
6) BR-316 (R06)
   - widening to 8 lanes from Ananindeua to Icoaraci (8.4km)
7) PA-150 (R07)
   - new construction road as the Para state highway (25.6km)
8) Av. Pedro Miranda Extension (R08)
   - new construction road passing through Institutional Belt (5.3km)
9) Rodvia Aura (R09)
   - new construction road between Cidade Nova and Aura (14.6km)
10) Rodvia Industrial (R10)
   - new construction road to access to the industrial area in Ananindeua (13.4km)
11) Local Arteries in Satelite Area (R11)
   - new construction road to access between the Satelite and the neighboring Maguari housing estates (4.6km)
12) Icoaraci Bypass (R12)
   - new construction road to access to the Icoaraci Industrial area (7.0km)
13) Local Artries in Cidade Nova (R13)
   - new construction road of local arteries in Cidade Nova (5.8km)
14) Estrada do 40 Horas (R14)
   - new construction road to extend PA-150 (3.6km)
15) Av. Alicindo Cacella/Trv. 9 de Janeiro (R15 and R16)
   - new construction road to extend to the flood area of Una river (3.9km) and pavement of Av. Alicindo Cacella

16) Av. Bernardo Sayao (R17)
- widening to 4 lanes (7.2km)

17) Inner Ring Road (R18)
- construction of new circumferential road (1.9km)

18) Extension of Trv. Humaita/Trv. Loma (R19 and R20)
- new construction road (1.7km and 1.7km)

19) Una River Road (R21)
- new construction road between at intersection between Av.A.Cacella/P.Miranda and on R19 project (4.3km)

20) Trv. 14 de Marco Extension (R22)
- new construction road up to Trv.Alferes Costa (2.7km)

A summary of the road project cost by project is shown in Table 9.1-1.

Table 9.1-1 Road Project Cost Summary (1 US$= 88 CR$)

ID	Project Name	Dist. (km)	Total Financial Foreign (1000US$)	Total Financial Local (1000Cr$)	Total Economic Local (1000Cr$)	(F%)	Financial Cost (MUS$)	Economic Cost (MUS$)
R001	P. Cabral	2.54	1260.55	328303	245088	25.3	4.99	4.05
R002	1o.de Dez.(6)	22.34	10934.16	3357229	2619781	22.3	49.08	40.7
R003	Rod.Belem(6)	16.54	12764.82	4590411	3525100	19.7	64.93	52.82
R004	Val de Cans B/	6.31	1854.62	559776	422715	22.6	8.22	6.66
R005	Alm. Barroso	6.1	1342.73	266492	186962	30.7	4.37	3.47
R006	BR-316(6)	8.35	5187.75	1331459	1001225	25.5	20.32	16.57
R007	PA-150	25.56	7710.76	2481443	1911065	21.5	35.91	29.43
R008	P. Miranda	5.29	2483.17	832559	663806	20.8	11.94	10.03
R009	Rod. Aura	14.63	5111.73	1456528	1091020	23.6	21.66	17.51
R010	Rod. Ind.	13.39	4029.76	1212952	915517	22.6	17.81	14.43
R011	Satelite	4.63	1397.21	423836	320421	22.5	6.21	5.04
R012	Icoaraci B/P	6.96	2096.36	599198	444025	23.5	8.91	7.14
R013	Cidade Nova	5.8	1730.68	498200	371455	23.4	7.39	5.95
R014	40 Horas	3.6	1076.19	306047	227366	23.6	4.55	3.66
R015	Alc. Cacela	0	0	0	0	0	0	0
R016	9 de Janeiro	3.86	1630.92	485224	363422	22.8	7.14	5.76
R017	B. Sayao	7.22	6270.66	2625658	2026526	17.4	36.11	29.3
R018	Inner Ring	1.92	580.59	163442	120472	23.8	2.44	1.95
R019	Humaita	1.68	506.85	231363	193850	16.2	3.14	2.71
R020	Loma	1.68	506.85	198627	161112	18.3	2.76	2.34
R021	Rio Una	4.27	3191.06	1399091	1082342	16.7	19.09	15.49
R022	14 de Marco	2.74	825.63	278838	217724	20.7	3.99	3.3
	Total	165.41	72493.04	23626677	18110995	21.3	340.98	278.3

Figure 9.1-1 Road Project Map

9.2 Priority Ranking of Road Projects

The priority of projects should be studied taking into consideration the following elements;

a. Effect on decreasing traffic congestion in entire road network,
b. Cost performance of projects from the economic standpoints,
c. Convenience for road users,
d. Financial influence for the executing agency,
e. Influence to communities,
f. Project consensus,
g. Compatibility with policy, and
h. East of implementation.

(1) Cost Benefit

The benefit of road projects is defined as the vehicle operating cost (VOC) saving in terms of economic price. The VOC saving could be calculated as the follow.

> the difference between the total VOC in the case where a project in the Masterplan network will not be executed and the total VOC in the Masterplan network.

To compare the benefits of the projects, the benefits of each project in one year, the year 2010, are calculated so as to eliminate the influence by the variance of the implementation schedule.

The construction cost of a project should be expressed on an annual base in calculating B/C of a project in the year 2010. For this purpose, the formula to make annual repayment of principal and interest at one rate for 25 years.

Figure 9.2-1 shows the scattered graph of B/C and the net benefit by road projects.

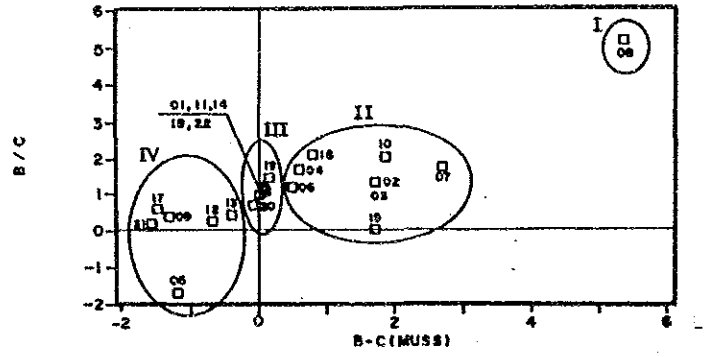

Figure 9.2-1 Project Grouping by B/C and B-C

Based on Figure 9.2-1, the projects can be aggregated into the following four groups.

(1) The first group
The project with high net benefit and B/C is only Av. Pedro Miranda Extension (R08)

(2) The second group
The projects with medium net benefit and B/C beyond 1.0 include Av. 1o de Dezembro (R02), Rodvia do Belem (R03), PA-150 (R07), Rodvia Industrial (R10), and Trv. 9 de Janeiro (R16).

(3) The third group
The projects with less net benefit and with less costs include Av. Pedro Cabral (R01), Local Arterials in Satelite (R11), and Estrada 40 Horas (R14).

(4) The fourth group
The projects with negative net benefit, and with comparatively high costs aiming to improve living environment rather than to save VOC include Una River Road (R21) and Av. Bernardo Sayao (R17).

(2) Priority Ranking of the Projects

To calculate the priority ranking of the projects, the following elements are considered in addition to the grouping by the net benefit and B/C.

a. Consensus
b. Social influence
c. Project stage

The comprehensive project priority is established by classifying the sum of the total points of evaluation elements into four categories as shown in Table 9.2-1.

Table 9.2-1 Comprehensive Project Priority Ranking

PROJECT ID	NAME	DIST (KM)	TOTAL FINANCIAL (MUS$)	TOTAL ECONOMIC (MUS$)	GP	CONS	SOCIAL	STAGE	TOTAL	RANK
	TOTAL	165.41	340.98	278.30						
R001	P. CABRAL	2.54	4.99	4.05	3	1	1	1	30	1
R002	1 DE 12(6)	22.34	49.08	40.70	2	1	3	2	40	2
R003	ROD BELEM(6)	18.56	64.93	52.82	2	3	3	3	55	4
R004	V/C B/P	6.31	8.22	6.66	2	1	2	2	35	2
R005	ALM. BARROSO	6.10	4.37	3.47	4	1	1	3	45	3
R006	BR316(6)	8.35	20.32	16.57	2	1	2	2	35	2
R007	PA-150	25.56	35.91	29.43	2	1	2	1	30	1
R008	P. MIRANDA	5.29	11.94	10.03	1	3	3	3	50	3
R009	ROD AURA	14.63	21.66	17.51	4	3	2	3	60	4
R010	ROD IND.	13.39	17.81	14.43	2	2	1	1	30	1
R011	SATELITE	4.63	8.21	5.04	3	2	1	2	40	2
R012	ICO B/P	6.96	8.91	7.14	4	3	2	2	55	4
R013	ACC. C. BOVA	5.80	7.39	5.95	4	2	1	2	45	3
R014	40HORAS	3.60	4.55	3.68	3	3	1	2	45	3
R015	A. CACELLA	0.00	0.00	0.00	2	1	1	1	25	1
R016	9 DE 1	3.86	7.14	5.76	2	1	3	1	35	2
R017	A. SAYAO	7.22	38.11	29.30	4	2	2	2	50	3
R018	J. KING	1.92	2.44	1.95	3	3	2	2	50	3
R019	HUMAITA	1.68	3.14	2.71	3	2	1	1	35	2
R020	LOMA	1.68	2.78	2.34	3	2	1	1	35	2
R021	RIO URA	4.27	19.09	15.49	4	1	2	2	45	3
R022	14 DE 3	2.74	3.98	3.30	3	2	2	2	45	3

The projects with high priority are such arteries in the suburban area as PA-150 (R07) and Rodvia Industrial (R10). The projects with less priority are Rodvia Belem (R03), Rodvia Aura (R09), etc. Those less priority projects are caused by aspects of land acquisition and consensus of implementation.

9.3 Implementation Schedule of Road Projects

Figure 9.3-1 shows the average congestion rates (V/C) of each case. The average congestion rate in 1990 is 0.39 and it will increase up to 0.88 in the year 2010 under the "Do Nothing" case. If the projects in the priority ranking 1 and 2 are implemented by the year 2000 and all the projects by the year 2010, the average congestion rate will be increase gently up to 0.53 in the year 2010, almost the same rate as that in the present can be maintained. If the projects in the priority ranking 3 or 4 and 4 are implemented by the year 2000, the average congestion rate will decrease below the rate at present indicating over investment judging from the traffic situation at present.

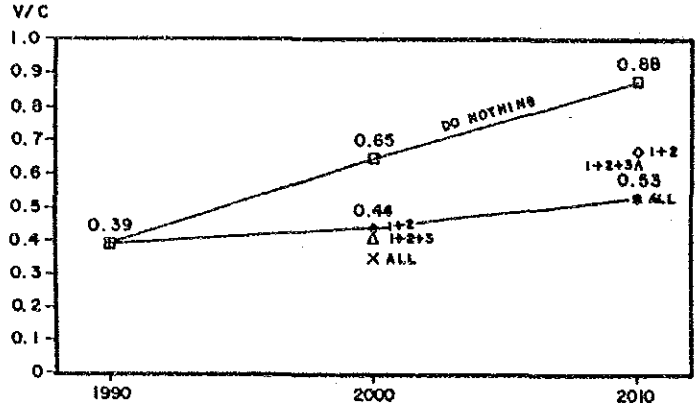

Figure 9.3-1 Average Congestion Rates by Priority Rank and Year

Figure 9.3-2 shows the road project implementation schedule established taking the road network in the year 2000 into consideration.

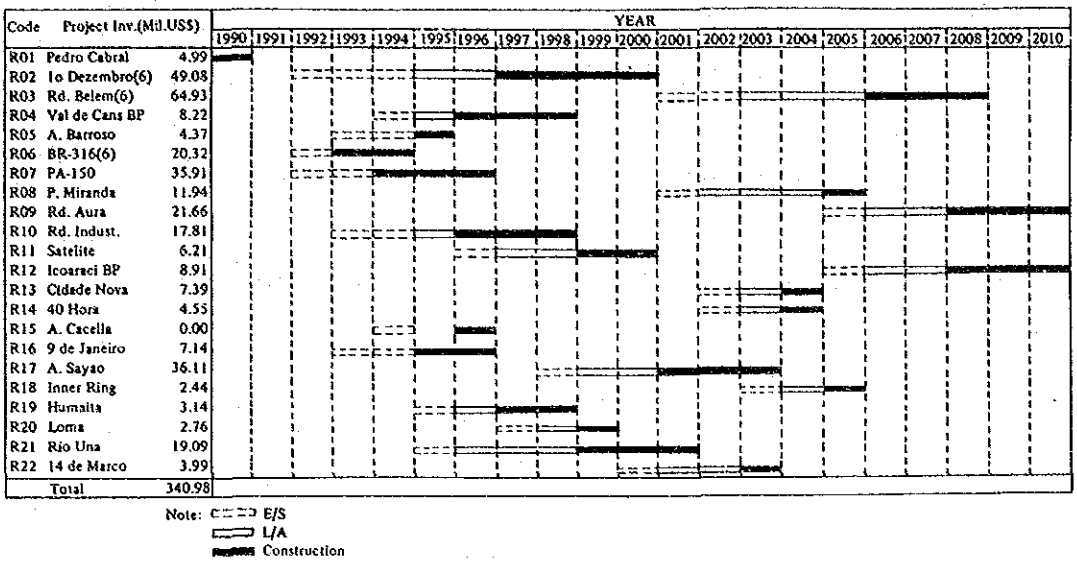

Figure 9.3-2 Implementation Schedule

10. PUBLIC TRANSPORT PLAN

10.1 Alternative Network

The following five fundamental alternatives are proposed.

1) Alternative No.1
   Present bus transport system and bus network

2) Alternative No.2
   Conventional bus operation system under the future master-plan road network

3) Alternative No.3
   Trunk/feeder integration system; 6 trunk routes, 2 main routes and four secondary routes

4) Alternative No.4
   Trunk/feeder integration system; 8 trunk routes and 4 secondary trunk routes

5) Alternative No.5
   Rail system from Ananindeua till Sao Braz through BR-316/Av. Almirante Barroso and some feeder routes for local service

The maximum passenger number at the intersection along BR-316/Av.Almirante Barroso is expected to be 540 thousand passengers per day in 2010. It is a sufficient figure to introduce rail system. The initial investment of rail system is estimated as 933 million US dollars. When the total budget scale for the master-plan implementation is considered, the difficulty to introduce rail system in Belem become evident.

The situation in 2010 of Alternative No.1 becomes chaotic in trunk axes. Av. Almirante Barroso/BR-316 counts 2,500-3,000 buses at peak hour. Under this situation, any bus and vehicle can not operate and run efficiently, respectively.

Table 10.1-1 comparison of alternatives in 2010

Alternative	R. Length (km)(A)	Psn No. (B)	Bus*km (C)	Psn*km (D)	B/A	B/C	D/C
1	2,230	3,700,002	1,200,355	40,977,073	1.659	3.1	34.1
2	2,158	3,466,621	832,814	27,135,105	1.606	4.2	32.6
3	542	6,069,248	617,619	29,582,377	11.198	9.8	47.9
4	719	5,548,471	650,275	31,406,347	7.717	8.5	48.3

Considering present situation of congestion from buses, an alternative which can be put in effect immediately is recommendable. When we adopt Alternative No.3, we have the advantage of an early start of several years. From this point of view adoption of Alternative No.3 seems a natural choice.

10.2 Bus Plan

Figure 10.2-1 shows route network of trunk/feeder integration bus system. Table 10.2-1 shows the detail contents of the trunk/feeder bus system of Alternative No.3. This plan requires 1,640 buses in the year 2010, of which 1,511 units are articular buses for trunk line and the other for regular size.

It is necessary that the administration of bus transport system be consolidated. To achieve this task the organization should be the one which sells the tickets and arrange the transport operation contracts with private bus companies. As a result, the money flow from transport users are first collected by the organization and then delivered to each private bus company.

The proposed projects are consisted of 7 bus terminals, 24 bus stops and exclusive bus lane with a total length of 48.6 km. The total costs sum approximately 39 million US$. Existing network shall be switched over in 1995.

10.3 Minibus Plan

The home interview survey shows that between 5 and 10% (difference depends on income class) of trips generated by persons with income above 40,000 NCZ$ (household income base) are taxi trips. Based on this fact we assume 15% of total trips from households with income above 40,000 NCZ$ might be the potential demand base for minibus service.

The service routes for minibus are shown in Figure 10.3-1 in which 6 routes are served by middle class bus with 29 seats.

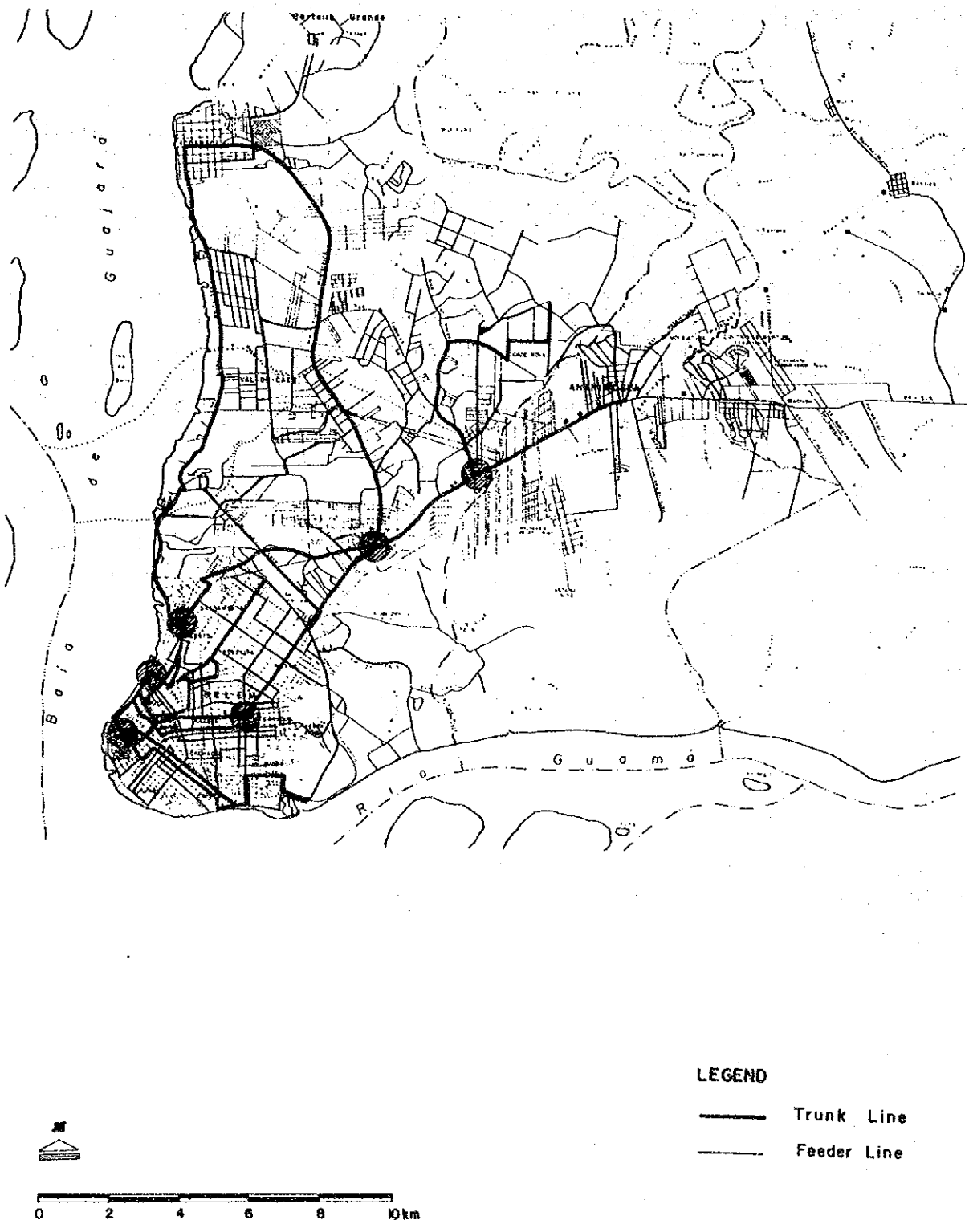

Figure 10.2-1 Route Network of Trunk/Feeder Bus System (Alternative No.3)

Table 10.2-1 Detail Contents of Trunk/Feeder Bus System (Alternative No.3)

Simulation Result
Case: Alt-3 (2010)

Route No	Route Name	Dist	Cacial Speed	Capacity	Pax No	Thru Pax No	Service (Peak Hr)	Times (Day)	Bus Fleet
1	Marituba/Ananindeua	9.6	21	110	14483	8961	9	161	5
2	Distrito Industrial/Ananindeua	7.7	21	110	67306	36303	37	628	14
3	Curucamba/Ananindeua	13.8	21	110	149199	73455	75	1271	50
4	Julia Seffer	8.1	21	110	129031	70542	72	1221	29
5	Cidade Nova/Ananindeua	14.3	21	110	44111	16697	17	289	12
6	Icui/Coqueiro	10.5	21	110	120434	65786	67	1139	34
7	Cidade Nova/Coqueiro	7.1	21	110	3877	2230	6	114	3
8	40 Horas	4.0	21	110	79012	43739	45	757	9
9	Coqueiro/Augusto Montenegro	10.2	21	110	99735	33393	34	578	17
10	Satelite/Augusto Montenegro	3.6	21	110	88814	48809	48	810	9
11	Jaderlandia/Augusto Montenegro	6.3	21	110	19540	10488	11	184	4
12	Transcoqueiro/Augusto Montenegro	6.4	21	110	8531	3519	6	114	3
13	Distrito Industrial/Icoaraci	22.4	21	130	96667	42970	37	629	40
14	Maguari/Augusto Montenegro	4.2	21	110	38598	20459	21	354	5
15	Arthur Bernardes/Augusto Montenegro	9.4	21	110	49148	24867	25	430	12
16	Cordeiro de Farias/Augusto Montenegro	9.9	21	110	43307	22179	23	384	12
17	Bengui/Augusto Montenegro	6.7	21	110	275	152	6	114	3
18	Bengui/Arthur Bernardes	19.4	21	130	24803	7788	7	124	7
19	Marambaia/Almirante Barroso	11.2	21	160	122498	59645	37	631	21
20	Tavares Bastos/Almirante Barroso	7.7	21	160	30831	17058	11	183	5
21	Aeroporto/Almirante Barroso	16.8	21	130	196879	66526	57	974	47
22	CEASA/Almirante Barroso	8.9	21	110	26494	12870	13	223	6
23	Universidade/Almirante Barroso	12.1	18	110	35831	18807	19	326	14
24	Perimetral/Senador Lemos	12.4	18	110	85895	22194	23	384	17
25	Bernardo Sayao/Nazare	6.4	14	110	144616	69718	71	1207	33
26	Bernardo Sayao/Marechal Hermes	11.4	14	110	186804	76761	78	1329	65
27	Universidade/Seo Braz	10.8	14	130	134799	72540	62	1062	49
28	Dr. Freitas/Sao Braz	6.4	16	110	47981	23663	24	410	13
29	Pedro Alvares Cabral/Almirante Barroso	7.4	16	110	3285	2040	6	114	4
30	Perimetral/Sao Braz	6.5	15	130	40423	20267	17	297	8
32	Pedro Miranda/Sao Braz	8.6	16	130	190989	99760	86	1461	47
33	Pedro Alvares Cabral/Perimetral	11.4	16	110	108524	43577	44	754	33
34	Pedro Alvares Cabral/Gentil	8.3	15	110	69715	40722	41	705	24
36	Princesa Isabel/Padre Eutiquio	9.1	15	110	30486	7966	8	146	6
38	Cremacao/Nazare	6.5	15	110	12407	12407	13	215	6
39	9 de Janeiro/Sao Braz	6.9	16	110	40031	23164	24	401	11
41	Montepio/Batista Campos	8.9	15	110	18451	18451	19	319	12
42	Troncal BR-316/Almirante Barroso	42.7	16	160	1512427	356669	222	3773	593
43	Troncal Augusto Montenegro/Pedro Alvares Cabral	51.2	18	160	853683	250393	156	2649	444
44	Troncal Icoaraci/Pedro Alvares Cabral	35.5	18	160	190535	72427	45	766	90
45	Troncal Cidade Nova	27.8	18	160	398707	186637	116	1974	179
46	Troncal Pedro Miranda/Presidente Vargas	13.2	16	160	209721	98568	61	1043	52
47	Troncal Universidade/Padre Eutiquio	18.7	15	160	319367	117429	73	1242	92
Average		12.6	-	-	141145.3	53966.9	43.5	741.6	49.7
Total		542.1	-	-	6069248	2320576	1871	31890	2139

Route No	Route Name	Cong Rate	Bus*Km	Psn*Km	Psn/Km	Psn/ (Bus*Km)	(Psn*Km)/ (Bus*Km)	Cost	Ticket Sales	Sales/ Cost
1	Marituba/Ananindeua	1.0	1541	43765	1512	9.4	28	978	-	-
2	Distrito Industrial/Ananindeua	1.0	4838	113748	8741	13.9	24	3071	-	-
3	Curucamba/Ananindeua	1.0	17495	460566	10843	8.5	26	11106	-	-
4	Julia Seffer	1.0	9890	434740	15930	13.0	44	6278	-	-
5	Cidade Nova/Ananindeua	1.0	4127	170389	3089	10.7	41	2620	-	-
6	Icui/Coqueiro	1.0	11934	631074	11492	10.1	53	7575	-	-
7	Cidade Nova/Coqueiro	0.4	814	11273	543	4.8	14	517	-	-
8	40 Horas	1.0	3059	159604	19557	25.6	52	1942	-	-
9	Coqueiro/Augusto Montenegro	1.0	5919	266410	9740	16.9	45	3757	-	-
10	Satelite/Augusto Montenegro	1.0	2917	159865	24671	30.4	55	1852	-	-
11	Jaderlandia/Augusto Montenegro	1.0	1164	48951	3092	16.8	42	739	-	-
12	Transcoqueiro/Augusto Montenegro	0.6	725	13760	1493	13.1	19	460	-	-
13	Distrito Industrial/Icoaraci	1.0	14097	305537	4515	6.9	22	8949	-	-
14	Maguari/Augusto Montenegro	1.0	1480	67183	9233	26.1	45	940	-	-
15	Arthur Bernardes/Augusto Montenegro	1.0	4063	102646	5205	12.1	25	2579	-	-
16	Cordeiro de Farias/Augusto Montenegro	1.0	3808	81633	4366	11.4	21	2417	-	-
17	Bengui/Augusto Montenegro	0.0	759	783	41	0.4	1	482	-	-
18	Bengui/Arthur Bernardes	1.0	2411	101064	1280	10.3	42	1530	-	-
19	Marambaia/Almirante Barroso	1.0	7041	609254	10977	17.4	87	4470	-	-
20	Tavares Bastos/Almirante Barroso	1.0	1403	87945	4025	22.0	63	891	-	-
21	Aeroporto/Almirante Barroso	1.0	16369	653878	11719	12.0	40	10391	-	-
22	CEASA/Almirante Barroso	1.0	1992	104183	2964	13.3	52	1264	-	-
23	Universidade/Almirante Barroso	1.0	3932	186767	2988	9.1	47	2496	-	-
24	Perimetral/Senador Lemos	1.0	4779	216290	5297	13.8	45	3034	-	-
25	Bernardo Sayao/Nazare	1.0	7735	250107	22561	18.7	32	4910	-	-
26	Bernardo Sayao/Marechal Hermes	1.0	15147	576543	16386	12.3	38	9515	-	-
27	Universidade/Seo Braz	1.0	11485	352300	12470	11.7	31	7291	-	-
28	Dr. Freitas/Sao Braz	1.0	3424	58510	5739	14.0	17	2174	-	-
29	Pedro Alvares Cabral/Almirante Barroso	0.4	848	9207	442	3.9	11	538	-	-
30	Perimetral/Sao Braz	1.0	1932	99748	8209	20.9	52	1227	-	-
32	Pedro Miranda/Sao Braz	1.0	12522	458253	22286	15.3	37	7949	-	-
33	Pedro Alvares Cabral/Perimetral	1.0	8629	269835	9486	12.6	31	5478	-	-
34	Pedro Alvares Cabral/Gentil	1.0	5879	250383	8359	11.9	43	3732	-	-
36	Princesa Isabel/Padre Eutiquio	1.0	1323	56023	3357	23.0	42	840	-	-
38	Cremacao/Nazare	1.0	1387	25501	1921	8.9	18	881	-	-
39	9 de Janeiro/Sao Braz	1.0	2759	83767	5818	14.5	30	1751	-	-
41	Montepio/Batista Campos	1.0	2836	76242	2078	8.5	27	1800	-	-
42	Troncal BR-316/Almirante Barroso	1.0	161097	9035937	35420	9.4	56	102264	-	-
43	Troncal Augusto Montenegro/Pedro Alvares Cabral	1.0	135476	7522335	16690	6.3	56	86000	-	-
44	Troncal Icoaraci/Pedro Alvares Cabral	1.0	27212	1699330	5364	7.0	62	17274	-	-
45	Troncal Cidade Nova	1.0	54409	2053765	14467	7.3	38	34539	-	-
46	Troncal Pedro Miranda/Presidente Vargas	1.0	13784	769473	15864	15.2	56	8750	-	-
47	Troncal Universidade/Padre Eutiquio	1.0	23178	893832	17115	13.8	39	14714	-	-
Average		1.0	14363.2	687962.3	11197	9.8	48	-	-	1.20
Total		-	617619	29582377	-	-	-	392065	2858101	-

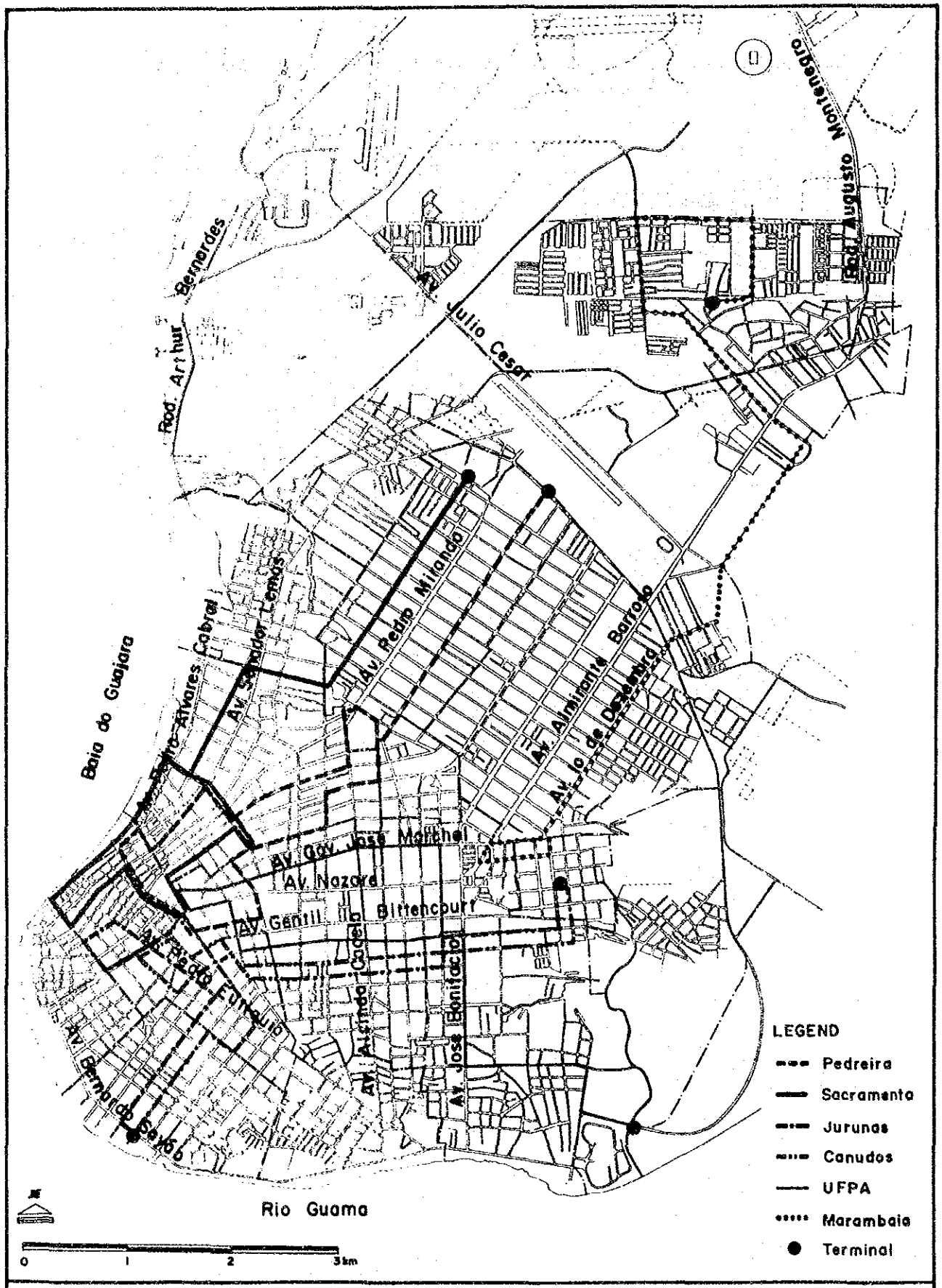

Figure 10.3-1 Minibus Routes

11. TRAFFIC MANAGEMENT PLAN

11.1 Basic Concept for Planning

Basic concept for the traffic management planning is to effectively use the existing traffic facilities in accordance with traffic demand at present and in the future. Although the road network density in the central area is sufficient, heavy traffic concentrates on a few major roads. Therefore, it is important to ensure smooth traffic flow in accordance with the future traffic demand by effectively using the existing traffic facilities.

The measurement for the masterplan of traffic management is "separation" of traffic. By "separation" of traffic flow, it is possible to maintain traffic safety and smooth traffic flow due to the existence of the same type of traffic on the roads. The type of traffic flow to be separated are as follows;

a. Public traffic and private traffic,
b. Inter-zone traffic and intra-zone traffic, and
c. Vehicles and pedestrians

11.2 Traffic Flow Plan

Road function plays a role in the separation of the traffic flow. The roads are classifies into three types: public traffic artery, private traffic artery and secondary street. Each road function is shown as follows.

1) Public traffic artery

On this road, bus is able to operate punctually with little interruption from other traffic. Bus has to run mixed with intra-zone traffic which is generated by residents by road-side.

2) Private traffic artery

This road is defined for inter-zone traffic which is important for private vehicles access between suburban area and CBD area. Therefore on this road, vehicles are required to drive at high speed. Parking restriction should be enforced.

3) Secondary street

This road is defined for intra-zone traffic which distributes within the zone. On-street parking is permitted for easy distribution and high travel speed is not required.

Figure 11.2-1 shows traffic flow plan. Figure 11.2-2 shows exclusive bus lane and Figure 11.2-3 shows parking restriction plan.

Figure 11.2-1 Traffic Flow Plan

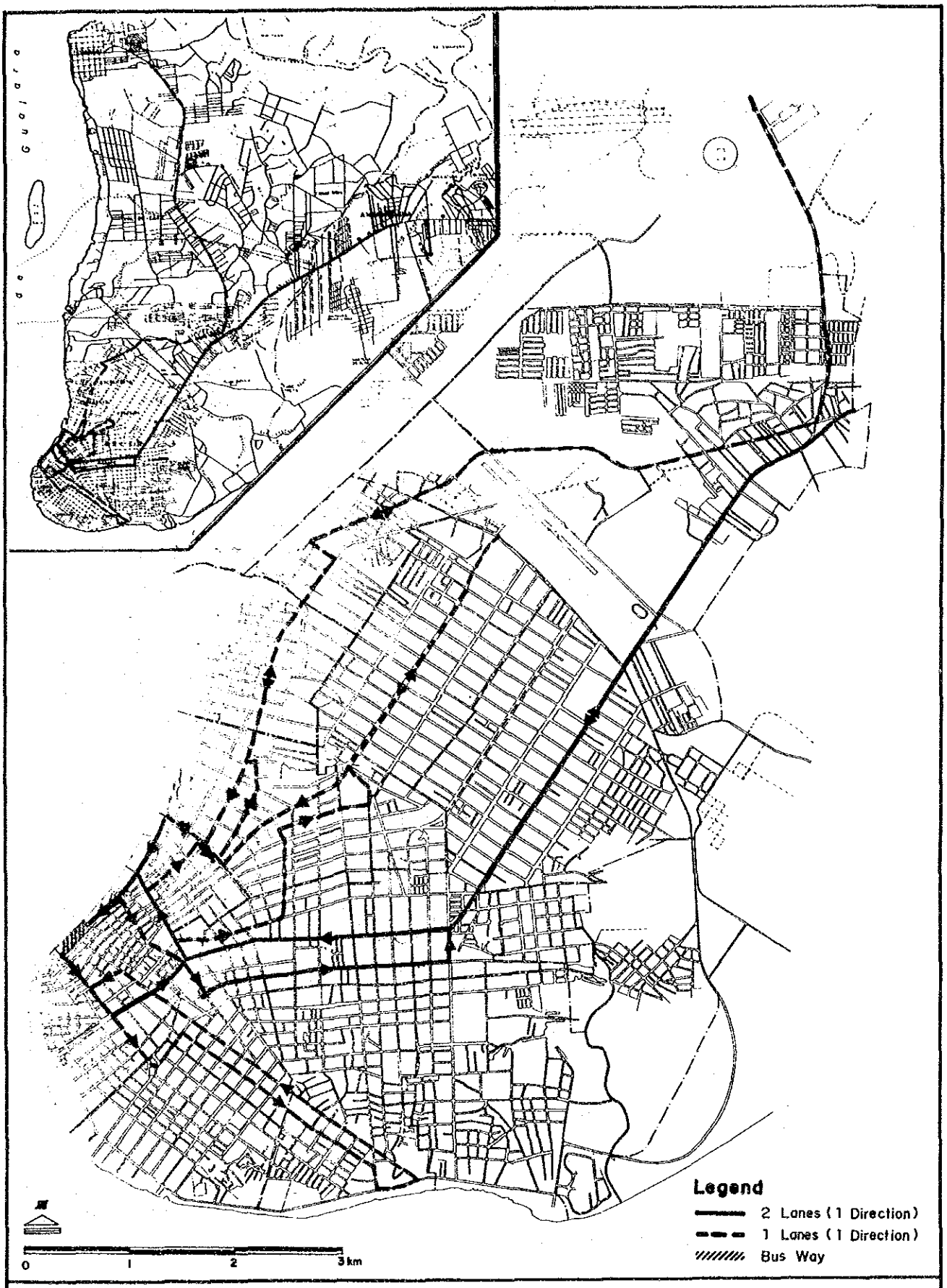

Figure 11.2-2 Exclusive Bus Lane

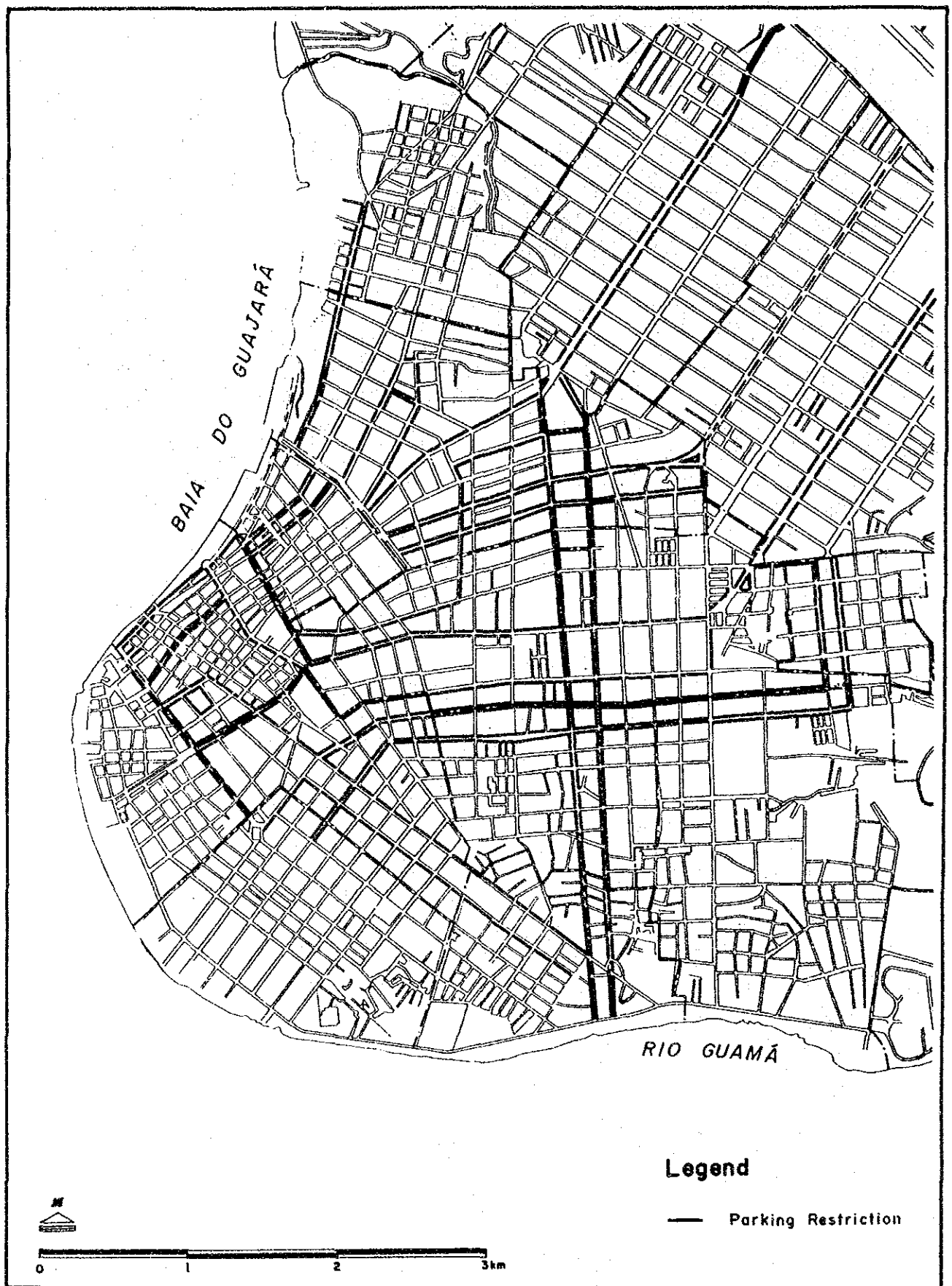

Figure 11.2-3 Parking Restriction Plan

11.3 Signal System Plan

Signal system plans are made by increasing the installations of signalized intersections, improving the signal system and synchronizing the signalized intersections. Until the year 2010, about 104 pedestrian signal sets in the central area, 85 sets of signalized system, and signal system center controlled by the controller are installed to maintain smooth vehicle movement (refer to Figure 11.3-1).

11.4 Others

The intersection improvement at four intersections, the road width enlargement at two road sections, sidewalk improvement, and installation of curb-parking on the secondary streets are planned as other road improvement projects (refer to Figure 11.4-1).

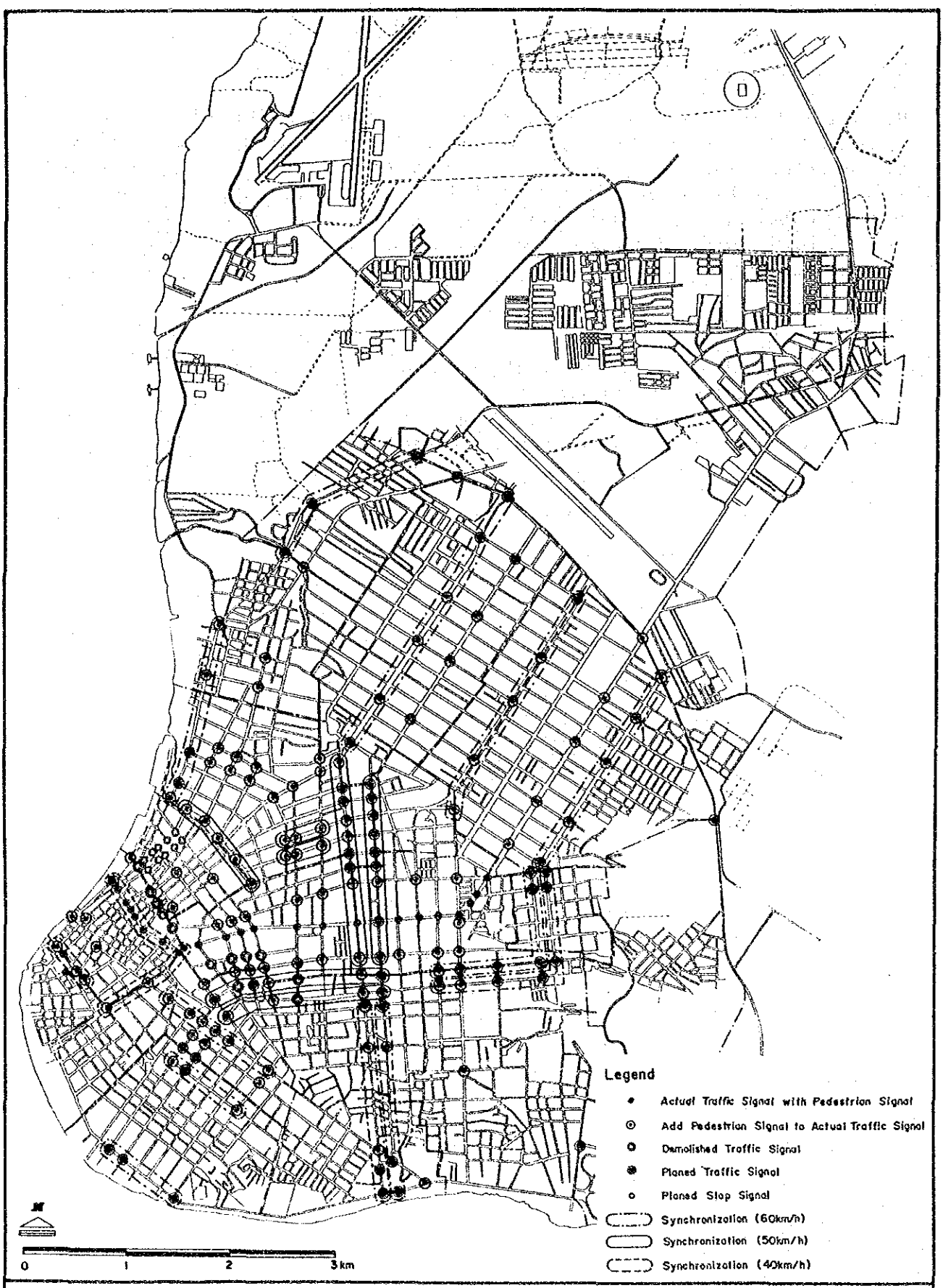

Figure 11.3-1 Location Plan of Traffic Signal

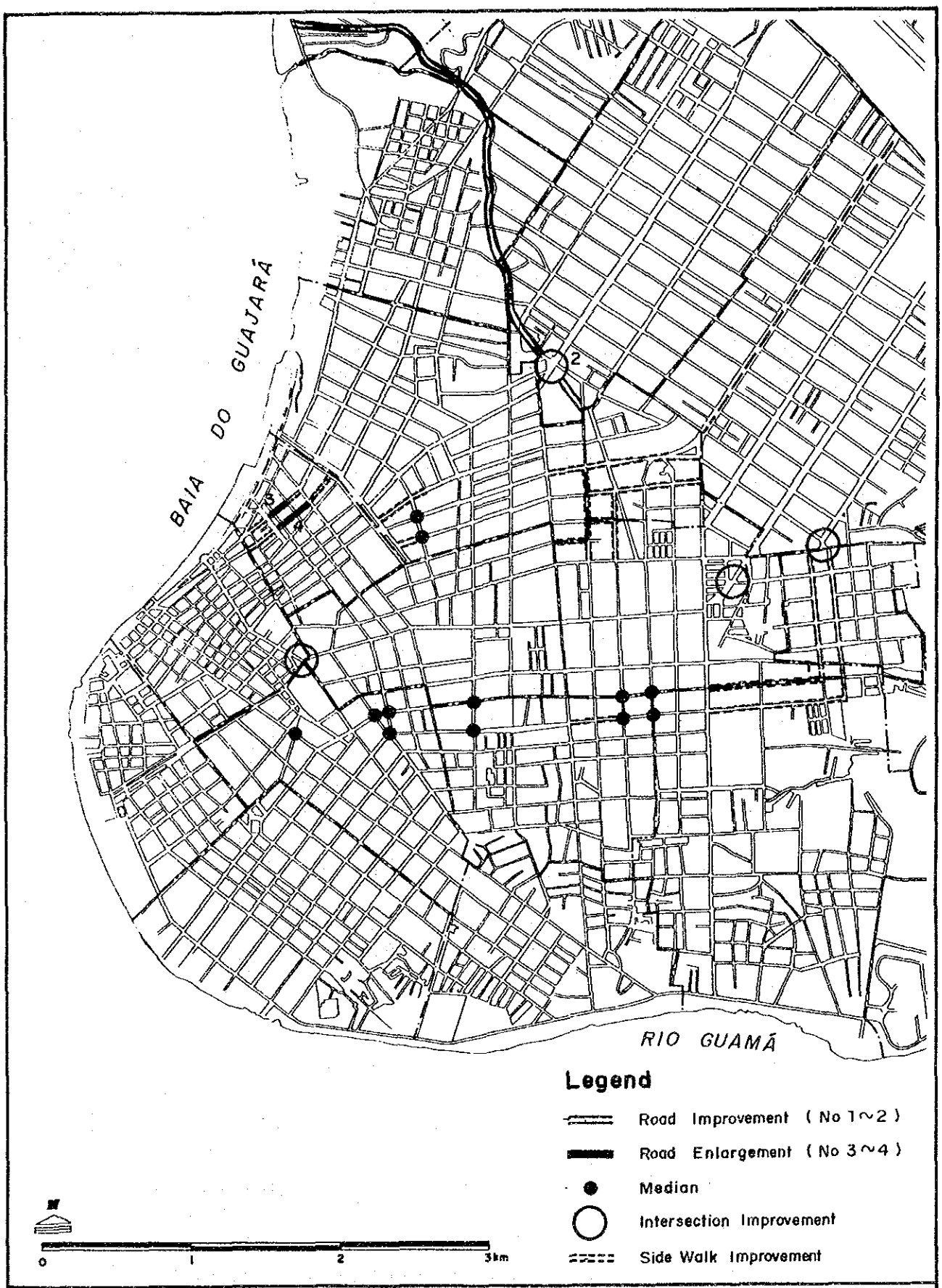

Figure 11.4-1 Road Improvement Project

12. INVESTMENT PROGRAM

12.1 Investment Program

All the projects in the Transport Masterplan in Belem are classified into 3 categories; road projects, public transport projects and traffic management projects. The total costs of these projects are approximately 390 million US$, of which 341 million US$ are estimated to be needed to carried out the road Masterplan, 42 million US$ are for the public transport projects and the remained 7.5 million US$ are for traffic management projects. Tables 12.1-12.3 show the implementation schedule for a period of two decades since 1990.

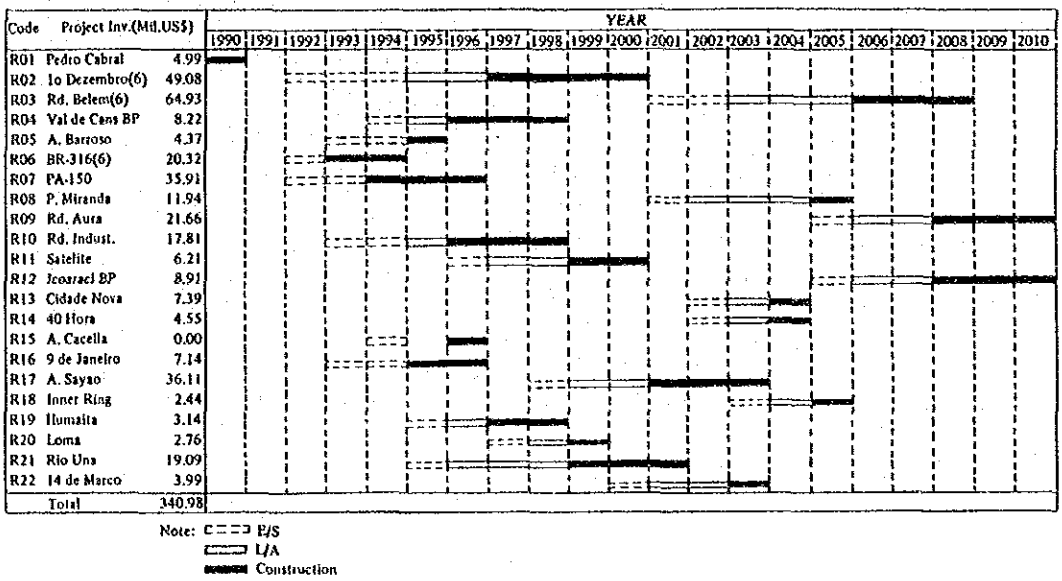

Figure 12.1 Road Investment Schedule

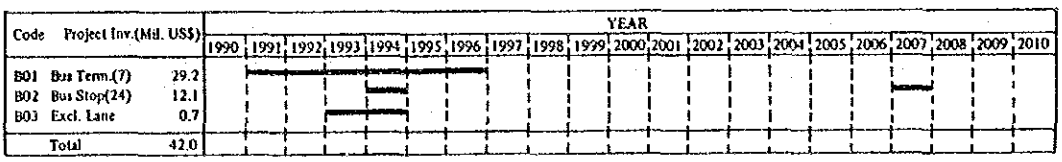

Figure 12-2 Public Transport Investment Schedule

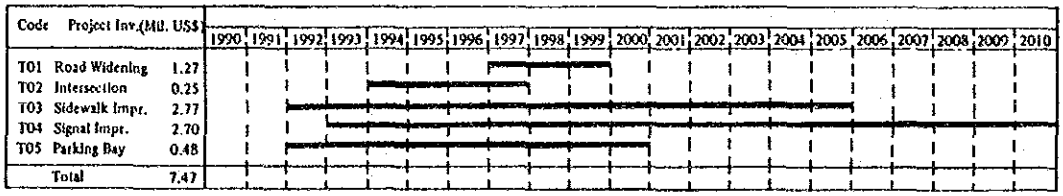

Figure 12-3 Traffic Management Project Schedule

12.2 Government Financial Situation

In order to carried out the proposed Masterplan, as possible financial sources, Para state, Municipality of Belem and Municipality of Ananindeua are considered. From among those local governments, Para state and Municipalities of Belem mainly implement the Masterplan projects under the limited budget.

The total annual income of the municipalities of Belem and Ananindeua in 1989 is approximately 728 million US$, of which 65.4 million US$ are for Belem and the other is for Ananindeua. The percentage share of the expenditure for transport sector from 1985 ranges approximately from 1.0% to 3.0% of the total income.

Current expenditure for the transport sector represents 1 to 3% of the State and Municipality budget. Assuming the one percent share is distributed for the implementation of Masterplan, the total amount of budget available for the next two decades is estimated at approximately 118 million US$. Total present value at 1990 means the available amount of financial resources subtracting the cost of borrowing when used at once in 1990. Since the actual expenditure for the implementation of Masterplan will be distributed over 20 years, the available amount becomes more than twice that show above.

The Federal Government had subsidized at high ratio for transport projects implemented by the local governments. Color Government, however, administrates under the policy which the subsidies are not recognized due to the fact that economic situation of Brazil is serious.

It is expected that in accordance with future economic improvement, the Federal Government subsides derived from Federal fund or from official foreign loans will be reopened. Assuming the Federal Government subsidies to be 30 to 50 percent of the total cost, the amount of budget available for Masterplan ranges from 350 to 500 million US$.

13. EVALUATION OF TRANSPORT MASTERPLAN

13.1 Economic Evaluation

Among the various benefits derived from the implementation of Masterplan, the two factors are counted as the economic benefit; (1) savings in vehicle operating cost and (2) savings in travel time cost. Total vehicle running distance in BMR is shown in Table 13.1 and total vehicle running time is also shown in Table 13.2. According to those Tables, the large part of saving in the total running distance and total running hour is attributed to the effects of the trunk/feeder bus system.

Table 13.1 Total Vehicle Running Distance (veh*km/day)

Year	Vehicle Type	Do-nothig	Masterplan	Difference
1995	passengercar	1,863	1,832	31
	taxi	299	296	3
	truck	300	294	6
	bus	743	117	626
	articular bus	-	248	-248
	Total	3,205	2,786	420
2010	passengercar	3,164	3,132	32
	taxi	468	473	-5
	truck	428	442	-14
	bus	1,200	198	1,003
	articular bus	-	420	-420
	Total	5,260	4,665	595

Source: Study Team

Table 13.2 Total Vehicle Running Hour (veh*hr/day)

Year	Vehicle Type	Do-nothing	Masterplan	Difference
1995	Passengercar	55,561	56,306	-745
	Taxi	10,629	9,830	799
	Truck	9,161	8,500	661
	Bus	30,504	3,353	27,150
	Articular bus	-	7,125	-7,125
	Total	105,855	85,114	20,740
2010	Passengercar	88,045	82,433	5,612
	Taxi	15,906	13,932	1,974
	Truck	12,253	12,200	53
	Bus	64,802	5,958	58,844
	Articular bus	-	12,660	-12,660
	Total	181,006	127,236	53,823

Source:Study Team

Since it is difficult to estimate the total effects of the Masterplan regarding road, public transport and traffic management simultaneously, the effects of traffic management are estimated separately. The total reduction of delay time at an intersection during the peak hour is estimated as shown in Table 13.3

Table 13.3 Reduction of Delay Time due to Synchronized Control (veh*hr/day)

	1995	2000	2010
Passengercar	48.0	110.3	145.2
Taxi	10.9	29.9	35.8
Truck	5.0	11.9	15.6
Total	63.9	152.1	196.6

The economic benefit derived from the Masterplan is estimated as shown in Figure 13.1.

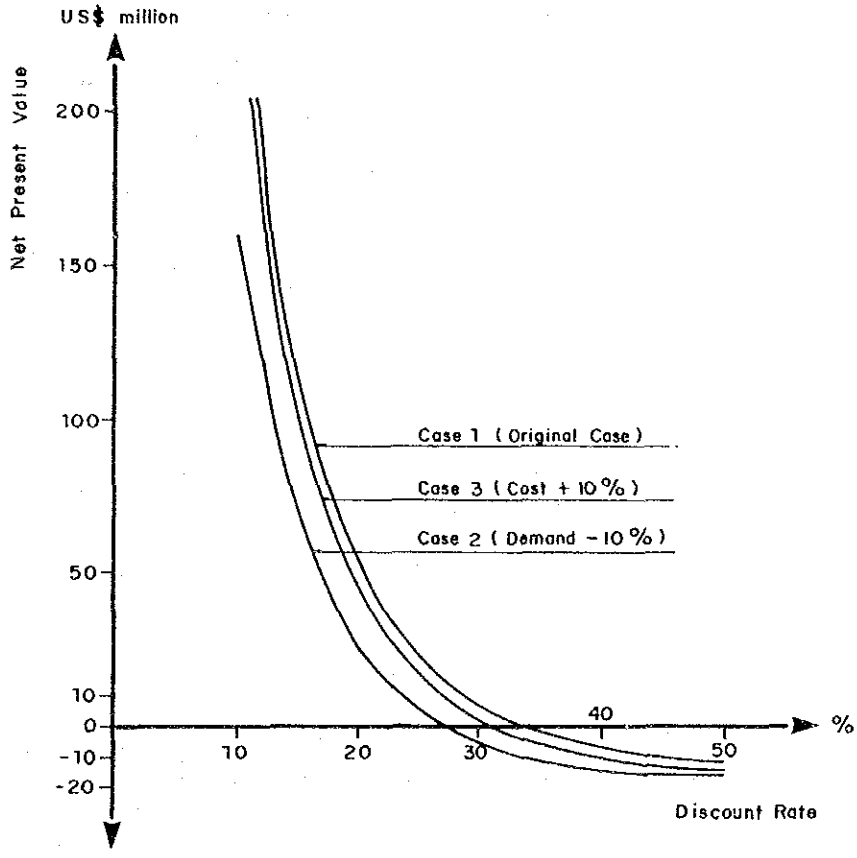

Figure 13.1 Economic Benefit

The total economic cost of the Masterplan is estimated at US$ 302.4 million. In order to examine the influence of future uncertain factors such as traffic demand and project cost, a sensitivity analysis is undertaken. The results of the evaluation indicators are shown in Table 13.4. According to the Table, the internal rate of return (IRR) is approximately 30%. Thus the Masterplan as a whole is highly economically viable.

Table 13.4 Economic Indicators for Sensitivity Analysis

Case		B/C	NPV (US$million)	IRR (%)
Case 1	Original Case	2.50	178.7	33.7
Case 2	Demand -10%	1.99	117.9	26.8
Case 3	Cost +10%	2.27	166.8	30.8

13.2 Financial Evaluation

In order to innovate the existing bus transport system, a trunk/feeder integrated system was proposed in this masterplan. This bus transport system is financially evaluated by examining the monetary inflow and outflow of the new organization.

Actual bus operation is carried out by private bus companies. In return, the bus companies will receive operation fee corresponding to the vehicle operating distance. The fee may include not only the operation cost but a relevant amount of profit for running the company.

A. Project Investment

The proposed system requires investment for the following projects.

a. Road improvement for bus such as bus exclusive lane and widening
b. Construction of bus terminals
c. Construction of bus stops

Other expenditures such as payment to bus operation and personal expenses are included in adding the above item.

B. Revenue

As for revenue of the new entity, the bus fare obtained from bus passengers is main revenue. As another revenue source, advertisement and rent for commercial and service activities can be envisage by making use of the advantageous conditions of bus terminal and ticket counters that provide in attracting many peoples. However, these are excluded from the analysis because it is more conservative from the financial viewpoint.

C. Conditions for Financial Evaluation

The financial evaluation is made under the following conditions.

a. The paid-up equity is assumed to be 10% of the total investment, and the rest should be covered by a loan.
   - Interest rate: 8 % p.a. (excluding BTN)
   - Repayment period: 10 years
   - Grace period: 4 years

b. The following taxes and duties are levied.
   - Corporation income tax: 30 % of profit
   - Duty for social contribution: 10 % of profit

c. The bus fare is assumed as CR$ 20 per passenger which is identical to the bus fare as of October, 1990. It is also assumed that bus transfer is allowed without any extra-charge.

d. Bus operating fees are paid to bus companies according to the vehicle operating distance. As for additional portion which covers corporation tax and profit, 5% of the bus operating cost is assumed.

e. Project life is assumed to be 25 years for all the bus facilities and the residual value is estimated to be 10% of the initial investment.

Table 13.5 shows the results of a sensitivity analysis regarding construction cost of bus facilities, additional payment of bus operation fee to bus companies, and bus fare.

As a conclusion, the proposed bus system is sufficiently profitable. However, some problems occur together with the expansion of the payment to bus companies. That is the shortage of the cash in hand will make it difficult for the entity to bear the high interest rate of short term loan. Therefore, a careful financial management including timely revision of bus tariff system must be accomplished.

Table 13.5 Results of Financial Evaluation

Case	NPV (US$million)	B/C	FIRR (%)
Original Case	5.78	1.20	14.7
Construction Cost +20%	0.15	0.996	11.9
-20%	11.70	1.49	18.3
Additional Payment to Bus Companies (Original:5%)			
Case 1 : 3 % of VOC	21.06	1.71	20.2
Case 2 : 7 % of VOC	-9.50	0.68	5.2
Bus Fare Cr$ 22/passenger	92.65	4.13	37.7
Cr$ 25/passenger	222.95	8.52	58.1

Note: Case 1 and 2 are corresponding to those illustrated in Figure 15.3-1.

14. CONCLUSION AND RECOMMENDATION

The Masterplan Study of the Urban Transport in Belem has been carried out during the period November 1989 and March 1991. The Future Transport Masterplan composed of roads, public transport and traffic management for two (2) decades is proposed.

In order to meet the future growing traffic demand, the following road network links are required to be improved;

(1) road corridors connecting the central area and suburban area to increase their traffic capacity,

(2) network system in suburban area to formulate the traffic network for the regional development, and

(3) several road links so as to create the smooth traffic flow in the central area.

The projects are scheduled during the next twenty (20) years, however, several projects are to be implemented as soon as possible from socioeconomic viewpoint. Especially, until 1995, the improvement of public transportation system is emphasized. The following actions and projects are recommended to be made immediately;

a. establishment of public bus management organization responsible for planning, control and management of public bus operation in BMR,

b. detailed study on introduction of new public bus operating system consisting of trunk/feeder bus operations,

c. feasibility study on road improvement projects such as Av. 1o de Dezembro, BR-316 and PA-150,

d. initiation of the improvement of traffic signal system such as traffic signal control center, and

e. budgetary resource examination for the implementation of Masterplan (resource and amount).

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