403. Institutional areas are divided into seven functions as follows;

a. Areas for administrative, research and educational institutions,
b. Military areas,
c. Transportation areas (seaport and airports),
d. Public utility areas (power station, garbage area, etc.),
e. Public parks and greenery areas for recreation activity,
f. Preservation area for water reservoir, and
g. Reserved area for future development

404. Table 8.3-9 and Figure 8.3-3 show the up-to-dated inventory and location of institutional areas.

Table 8.3-9 Inventory of institutional areas

Name	Area(ha)	Authority in charge
State Administration Center	355	Para State Government
UFPA	251	Ministry of Education
FCAP and EMBRAPA	1607	Ministry of Education, Ministry of Agriculture
Military area (Zone 27,28)	316	Airforce
Military area (Zone 21,23,24)	95	Airforce
Port of Belem	22	Para Dock Company
Val-de-Caes International Airport	712	Airforce
Julio Cesar Local Airport	130	Airforce
CELPA's power station	206	Para Electricity Company
CELPA's transformer station	36	Para Electricity Company
Alacid Nunes Football Stadium	117	Para State Government
Guajara Metropolitan Park	447	Para State Government
District park (Zone 40)	62	
District park (Zone 50)	54	
District park (Zone 5101)	125	
District park (Zone 5102)	419	
District park (Zone 5201)	293	
COSAMPA (water reservoirs)	1558	Para Sanitation Company
Garbage area	26	Para State Government

Notes: UFPA; Federal University of Para
FCAP; University of Agrarian Science of Para
EMBRAPA; Brazilian Organization of Farming and Cattle-raising Survey
CELPA; Para Electricity Company
COSAMPA; Para Sanitation Company

8.3.3 Review of Development Control Plan

405. The development control plan for urban evolution was planned by Belem Municipality. The "Law of Urban Development of

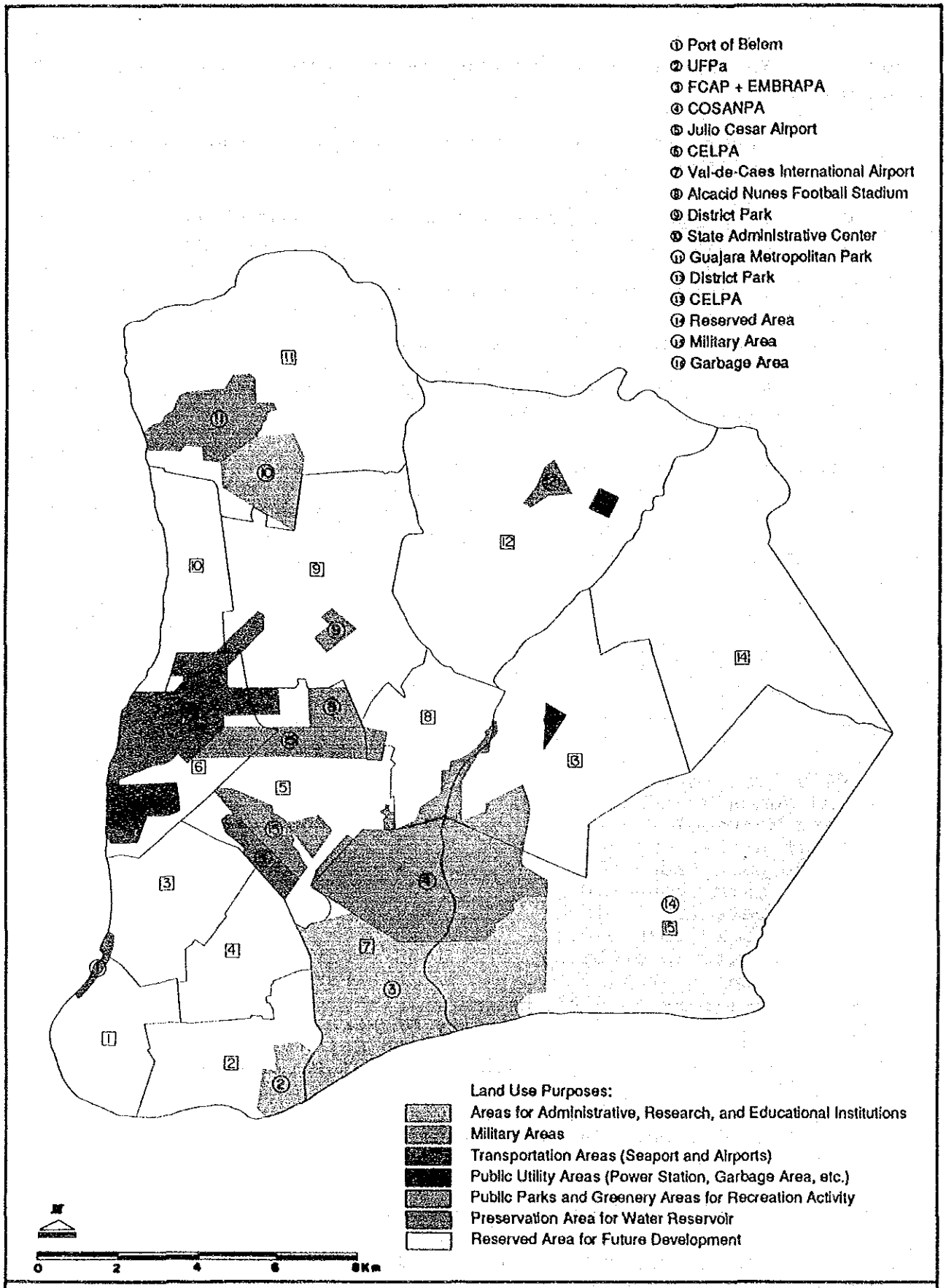


Figure 8.3-3 Institutional Land Use Plan

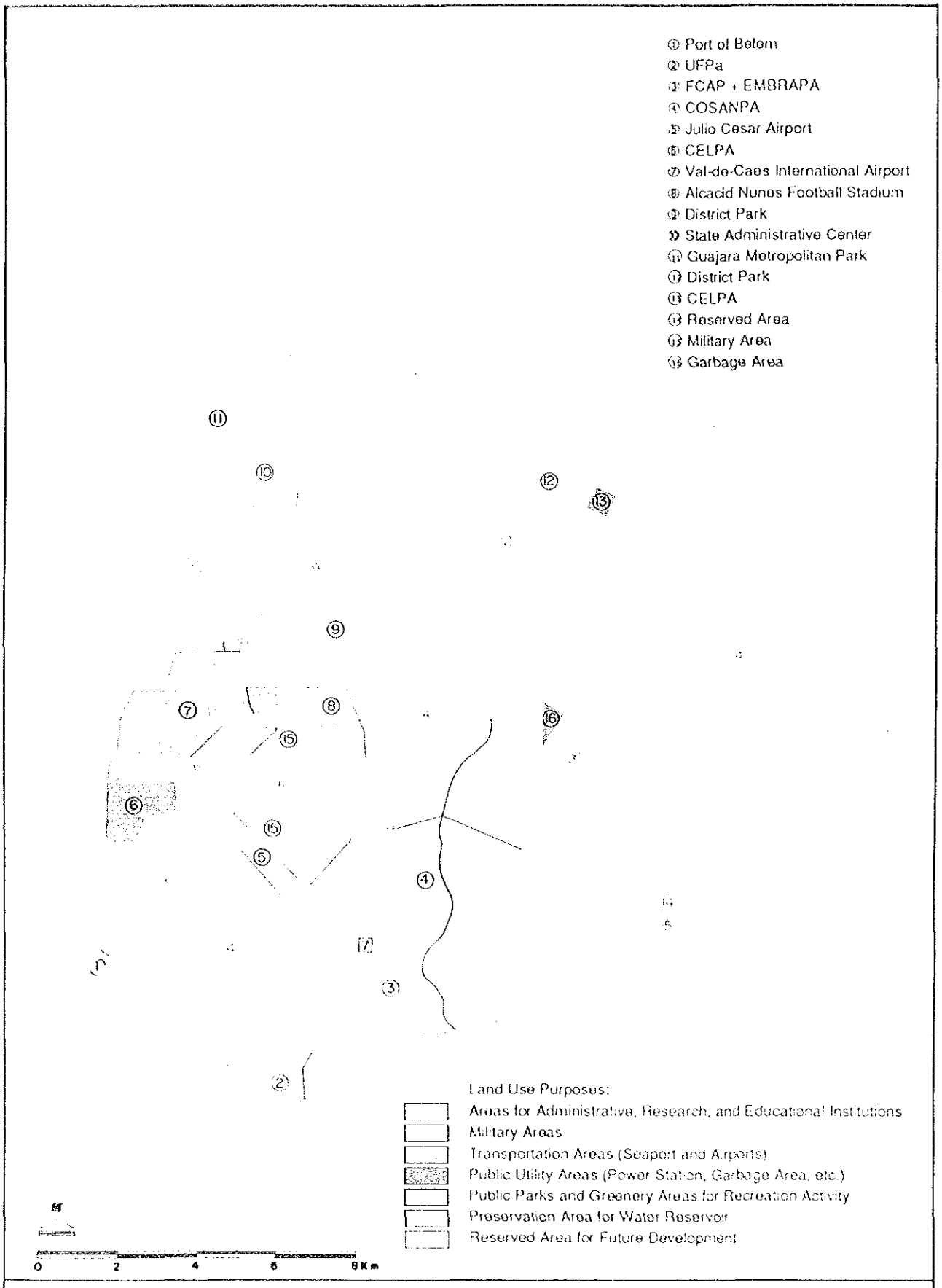


Figure 8.3-3 Institutional Land Use Plan

Belem Municipality", Law No. 7401 dated 1988 refers to the policy of urban development in the future. In this Study, general review of the current plan, above-mentioned, is examined for the purpose of adjustment of new land use scheme.

406. Major points for review are as follows;

a. Proposed control plan will cover the whole Study Area. At the present time, there is a lack of a plan in Ananindeua's municipality area (refer to Figure 8.3-4).
b. Partial change of control zoning system.
c. Element connected with the future demand of urban activities, especially residential area (refer to Table 8.3-10).

407. Proposed zoning system classifies the land of the whole Study Area into following five zones in accordance with the present situation of land utilization and prospective future urban activities. They are;

a. Residential zone,
b. Urban center zone,
c. Industrial zone,
d. Institutional zone, and
e. Rural zone (including reserved area for future development)

Table 8.3-10 Reference of zoning systems

Proposed system	Current system
Residential zone:	Habitation zone:
Type-A	H-5, H-6 and H-7
Type-B	H-4 (Central area)
Type-C	H-4, H-5 and H-6 (Outskirts area)
Type-D1	H-1 and H-4 (Outskirts area)
Type-D2	H-1 (Islands area)
Type-E1	H-2 and H-3
Type-E2	H-1 (beside water reservoir)
Urban center zone:	Commercial and services zone:
Designation of	Mixed-use zone:
Urban center districts	M-1, M-2, M-3 and M-4
Institutional zone:	Special function zone Preservation zone
Industrial zone:	same as above
Rural zone:	same as above

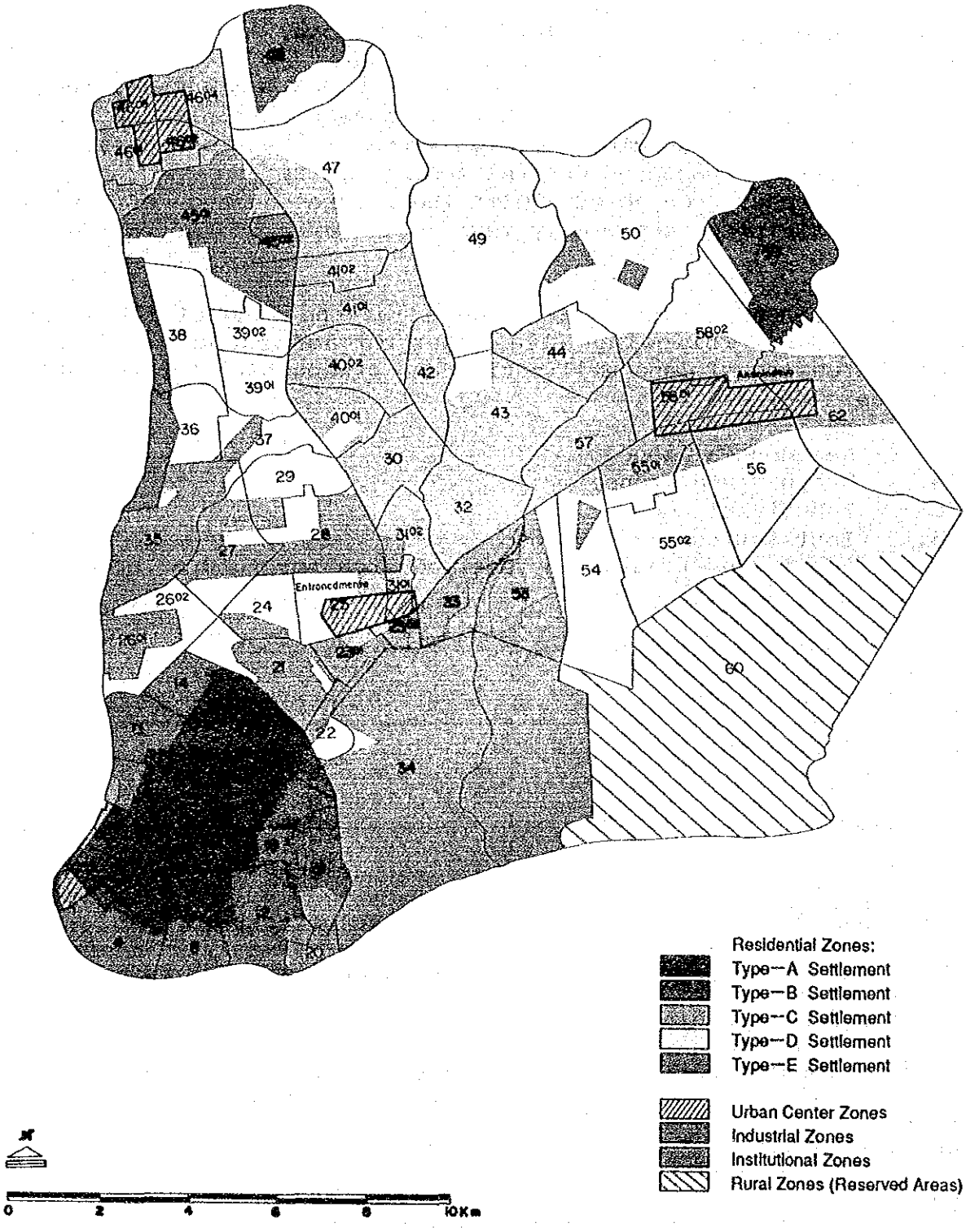


Figure 8.3-4 Development Control Plan (Proposed)

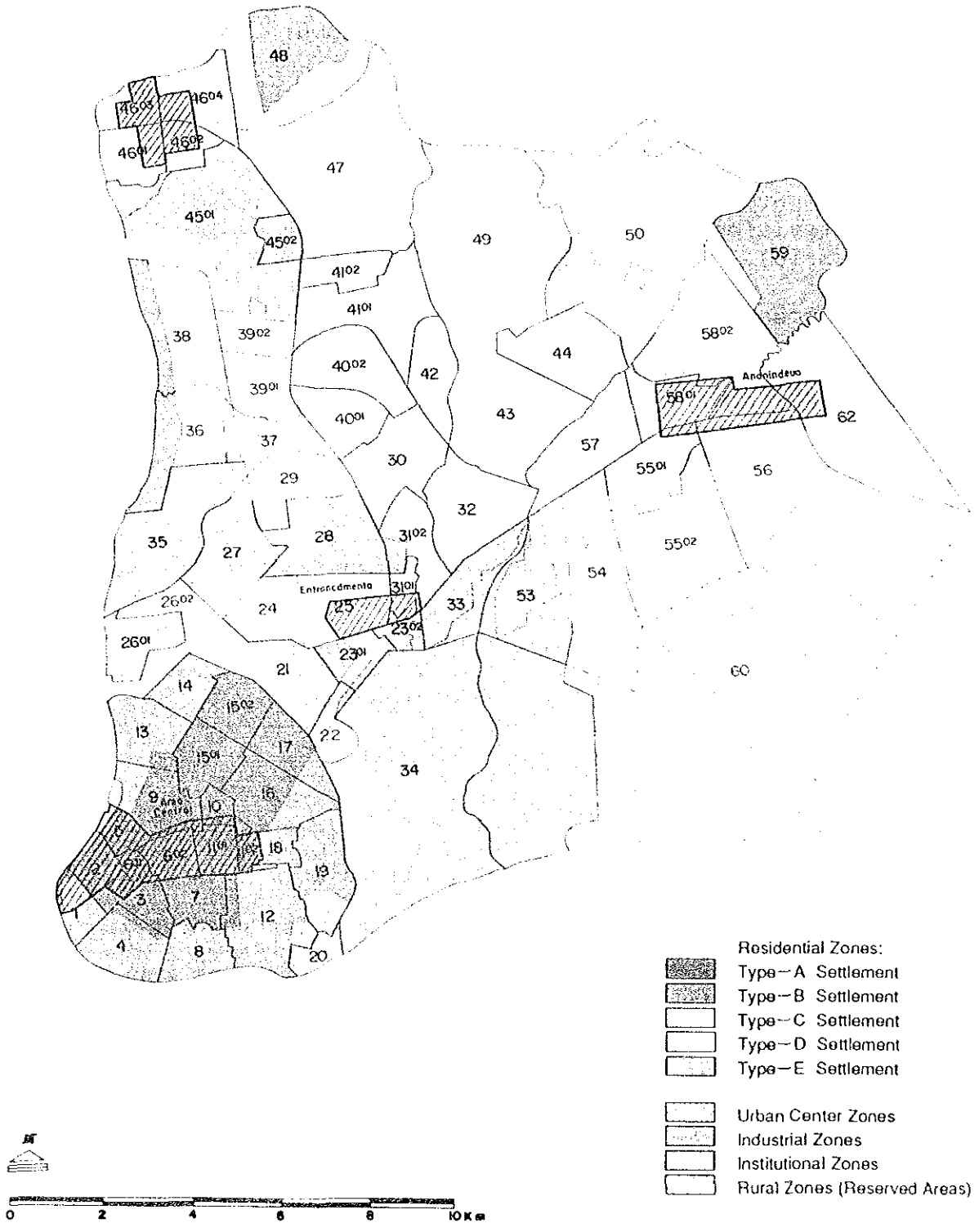


Figure 8.3-4 Development Control Plan (Proposed)

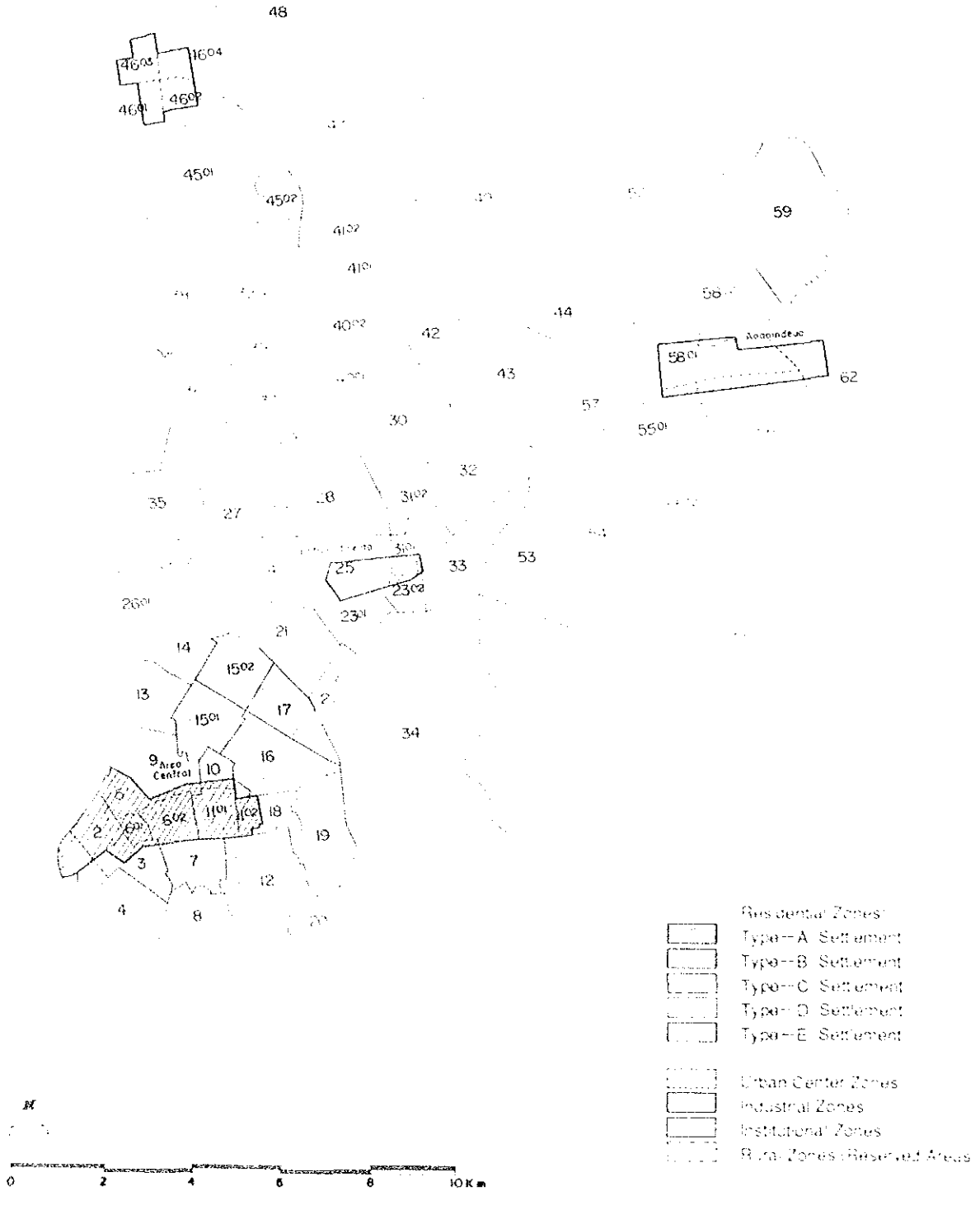


Figure 8.3-4 Development Control Plan (Proposed)

408. Table 8.3-11 and Figure 8.3-4 show the proposed area distribution and location of each control zone.

Table 8.3-11 Area list of the development control scheme

Zone types	Central area	Outskirts area	Islands area	Total (ha)
Residential zone:				
Type-A	1850	-	-	1850
Type-B	1641	-	-	1641
Type-C	-	7350	-	7350
Type-D	-	8731	7313	16044
Type-E	37	719	-	756
Subtotal	3528	16800	7313	27641
Urban center zone:	(550)	(730)	(-)	(1280)
Industrial zone:	-	1285	-	1285
Institutional zone:	185	5809	837	6831
Rural zone:	-	3557	23437	26994
Total	3713	27451	31587	62751

Notes: i) Urban center zones are overlapped with Residential zones. They are mixed-use with Type-A in Central area, and also mixed-use with Type-C in Outskirts area.

ii) Each area is corresponding to integrated zones;
Central area: zones 1 to 4
Outskirts area: zones 5 to 15
Islands area: zones 16 to 18.

409. Table 8.3-12 shows the composition of control zones by three (3) areas:

a. In the Central area, Residential zones are dominant use occupying 95%. The remaining 5% is for Institutional purposes. 14.8% of Residential zones (Type-A) are overlapped to Urban center zone, which is the Central Business District (CBD) of the Metropolitan Region of Belem.

b. In the Outskirts area, 61.2% is occupied by Residential zones, 21.1% for Institutional, 13.0% for Rural and 4.7% for Industrial purposes. Urban center zones, which include three Urban sub-centers, such as Ananindeua, Icoaraci and Entroncamento are overlapped to Residential zones (Type-C).

c. In the Islands area, 74.2% are occupied by Rural zones, 23.2% for Residential and remaining 2.6% for Institutional purposes.

Table 8.3-12 Composition of control zones (%)

Zone types	Central area	Outskirts area	Islands area	Total
Residential zone:				
Type-A	49.8	-	-	2.9
Type-B	44.2	-	-	2.6
Type-C	-	26.8	-	11.7
Type-D	-	31.8	23.2	25.6
Type-E	1.0	2.6	-	1.2
Subtotal	95.0	61.2	23.2	44.0
Urban center zone:	(14.8)	(6.3)	(-)	(2.0)
Industrial zone:	-	4.7	-	2.0
Institutional zone:	5.0	21.1	2.6	11.0
Rural zone:	-	13.0	74.2	43.0
Total	100%	100%	100%	100%

410. For the purpose of urban evolution in the future, the current Development Control Plan is revised, and Table 8.3-13 shows the comparison between current and proposed zoning areas as classified for each zone.

Table 8.3-13 Comparison of zoning area proportion

Zone types	Proposed	Current
Residential zones	44.0%	38.3%
Urban center zones	(2.0)	3.0
Industrial zones	2.0	1.6
Institutional zones	11.0	10.6
Rural zones	43.0	46.5
Total	100%	100%

411. Table 8.3-14 shows the breakdown of control zone types to each integrated zone.

Table 8.3-14 Area list by integrated zones (unit:ha)

Zones	Residential	Urban center	Industrial	Institutional	Rural	Total
Zone 1	808	(360)	-	15	-	823
Zone 2	930		-	163	-	1093
Zone 3	1003	(23)	-	7	-	1010
Zone 4	787	(167)	-	-	-	787
Zone 5	1134	(130)	-	534	-	1668
Zone 6	413		18	926	-	1357
Zone 7	14		-	1827	-	1841
Zone 8	775		-	97	-	872
Zone 9	2255		-	148	-	2403
Zone 10	545		266	3	-	814
Zone 11	2567	(220)	307	802	-	3676
Zone 12	3915		-	90	-	4005
Zone 13	2168	(15)	-	250	-	2418
Zone 14	2345	(365)	694	-	-	3039
Zone 15	669		-	1132	3557	5358
Zone 16	2158		-	544	480	3182
Zone 17	-		-	-	6320	6320
Zone 18	5155		-	293	16637	22085
Total	27641	(1280)	1285	6831	26994	62751

Note: Urban center zone is overlapped to Residential zone.

8.3.4 Allocation of Population, Enrollment and Employment by Zone

412. Based on the concept of urban development and future land use plan, the allocation of the population, enrollment, employment, etc. are determined by zone and target years(2000 and 2010). (refer to Table 8.3-15)

413. Population growth of the Study Area is mostly in the suburban area, especially in the zones of Guanaba, Bengui, Pratinha, Icoaraci, Cidade Nova, J. Seffer and Ananindeua, where the population size is forecasted to grow by 1.5 to 5.5 times.

414. Despite the stagnation of the population growth in the central area, it will still produce the employment opportunities for more than half of the whole Study Area in future. Urban subcenters in Entroncamento, Icoaraci and Ananindeua will enlarge their population size and economic activities but will not be able to produce sufficient employment opportunities for the workers living in their areas except Ananindeua.

415. With regard to education facilities the same situation will continue, and although gradual enlargement of the facilities in the suburban areas is expected in accordance with the population growth, they will still be located in the core of the central area.

416. Allowing for possibilities of the great differences in the assumption of the socioeconomic framework and land use plan in future above described, the alternative of the allocation of population, enrollment and employment is shown in Table 8.3-16 (designating more concentration of population into Central area and more labor opportunities in Suburban area). This situation is briefly examined to investigate the influences on transport network.

Table 8.3-15 Allocation of Future Socioeconomic Indices

Int. Zone	Population (1990)	Employment(1990) Home Base	Primary	Secondary	Tertiary	Enrollment(1990) Home B.	School B.
Centro	143,648	52,697	1,185	22,187	152,335	13,170	33,384
Guama	221,901	80,479	287	6,984	34,944	14,951	13,642
Sacramenta	203,860	71,981	269	8,451	48,075	14,745	12,089
Marco	133,184	48,358	370	9,271	53,099	11,571	16,304
Marambaia	154,940	54,378	198	6,251	32,764	11,376	6,545
Aeroporto	50,560	15,951	54	2,077	10,457	2,388	721
Embrapa	318	89	251	698	3,726	33	396
Guanaba	63,990	20,056	129	2,803	14,979	3,454	1,367
Bengui	106,046	35,958	80	2,667	12,485	5,666	1,834
Pratinha	20,452	6,448	796	1,772	5,463	839	138
Icoaraci	96,610	37,094	1,617	6,609	20,802	3,352	2,210
Cidade Nava	113,784	38,858	182	1,875	12,044	7,252	1,956
J. Seffer	29,982	9,672	29	741	3,630	1,415	412
Ananindeua	52,748	15,877	252	4,130	13,838	2,182	1,496
Aura	495	99	12	15	83	25	4
Outeiro	4,914	1,884	42	633	2,023	112	20
Ilhas	0	0	14	0	0	0	0
Mosqueiro	11,792	3,923	197	567	3,448	686	680
Exterior	0	0	1,063	1,950	6,251	0	28
Total	1,419,224	493,784	7,027	79,601	407,076	93,225	93,225

Table 8.3-15 Allocation of Future Socioeconomic Indices (continued)

Int. Zone	Population (2000)	Employment(2000) Home Base	Primary	Secondary	Tertiary	Enrollment(2000) Home B.	School B.
Centro	152,660	69,900	1,050	24,100	166,900	16,320	46,570
Guama	236,310	102,280	230	8,370	58,950	17,780	17,470
Sacramenta	225,910	99,310	230	10,540	92,030	19,060	17,490
Marco	142,120	64,440	310	11,100	97,280	14,260	22,080
Marambaia	165,390	72,310	160	6,680	40,580	14,130	9,210
Aeroporto	67,760	28,380	40	2,460	14,710	3,170	1,300
Embrapa	350	120	220	780	4,370	40	520
Guanaba	82,920	33,220	110	3,440	23,010	5,050	2,170
Bengui	202,610	86,820	70	4,330	31,410	12,980	4,090
Pratinha	43,470	16,190	750	3,400	15,180	2,100	360
Icoaraci	121,450	56,900	1,320	16,950	32,580	4,640	3,070
Cidade Nava	220,850	91,000	160	3,680	30,850	14,420	3,780
J. Seffer	72,780	28,280	20	1,900	13,690	4,210	1,370
Ananindeua	142,420	54,460	210	19,380	43,070	6,730	5,410
Aura	500	120	10	20	130	30	0
Outeiro	5,700	2,680	30	750	3,250	150	30
Ilhas	0	0	10	0	0	0	0
Mosqueiro	13,800	5,590	170	670	5,510	930	1,040
Exterior	0	0	900	3,000	10,500	0	40
Total	1,897,000	812,000	6,000	122,000	684,000	136,000	136,000

Table 8.3-15 Allocation of Future Socioeconomic Indices (continued)

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

Table 8.3-16 Allocation Alternative of Future Socioeconomic Indices

Int. Zone	Population (2010)	Employment(2010) Home Base	Primary	Secondary	Tertiary	Enrollment(2010) Home B.	School B.
Centro	167,800	91,110	710	29,240	240,940	20,480	37,250
Guama	238,800	122,840	140	10,080	72,380	20,150	23,440
Sacramenta	289,100	150,760	120	12,740	94,740	27,730	20,820
Marco	179,300	96,990	180	12,790	99,830	21,570	24,930
Marambaia	170,000	88,420	100	8,820	65,280	16,280	10,160
Aeroporto	74,600	34,570	20	4,530	27,050	3,720	3,160
Embrapa	400	160	120	960	7,520	50	400
Guanaba	97,000	45,110	60	6,300	44,040	6,520	4,430
Bengui	282,500	141,950	40	11,420	63,640	20,560	16,190
Pratinha	68,500	30,320	620	8,870	35,110	3,640	2,830
Icoaraci	139,400	77,340	930	14,540	30,130	5,740	9,080
Cidade Nava	325,300	163,680	90	7,590	62,820	20,510	14,500
J. Seffer	157,000	74,780	20	11,980	63,500	10,410	6,960
Ananindeua	214,800	95,000	120	32,100	102,580	11,380	14,690
Aura	500	150	10	10	180	40	0
Outeiro	6,500	3,640	20	1,040	4,890	200	40
Ilhas	0	0	10	0	0	0	0
Mosqueiro	13,500	6,460	90	960	8,050	1,030	900
Exterior	0	0	600	3,320	19,080	0	60
Total	2,425,000	1,223,000	4,000	177,000	1,042,000	190,000	190,000

9. Future Travel Demand

Rural Residential Area ▼

9.1 Travel Demand Modeling System

417. As for estimating traveler demand for transportation facilities and services, the urban travel demand model commonly known as the "Four Step Method" was employed in the Study. The four step method is used to predict (1) the number of trips made within the Study Area by purpose, (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 by these trips.

418. The flowchart of forecasting model is shown in Figure 9.1-1. The model embodies by motorized and non-motorized households, by trip purpose and by mode corresponding to each step as shown in Table 9.1-1. This is because the number of daily trips for motorized household members is considerably higher than the non-motorized, and zonal origin-destination pair is different by trip purpose and by transportation mode from the analysis of travel demand structure by person trip.

419. As for estimating for traveler demand for non-residents who dwell outside the Study Area, the four step method was not applied, however, it was employed for the residents within the Study Area. Travel demand for non-residents was estimated by a simple estimation method based on trend analysis. This is because trip information for non-residents is not available, and additionally, the ratio of trips made by them to the total is as low as 0.6 % at present. The influence on the accuracy of estimated whole trips is little, even when the simple method is employed for non-residents.

Table 9.1-1 Model Structure

Step	Motorized/ Non-Motorized	By Purpose	By Mode
0) Trip Production	O	-	-
1) Trip Generation/ Attraction	O	O	-
2) Trip Distribution	O	O	_
3) Modal Split	O	O	O
4) Traffic Assignment	-	-	O

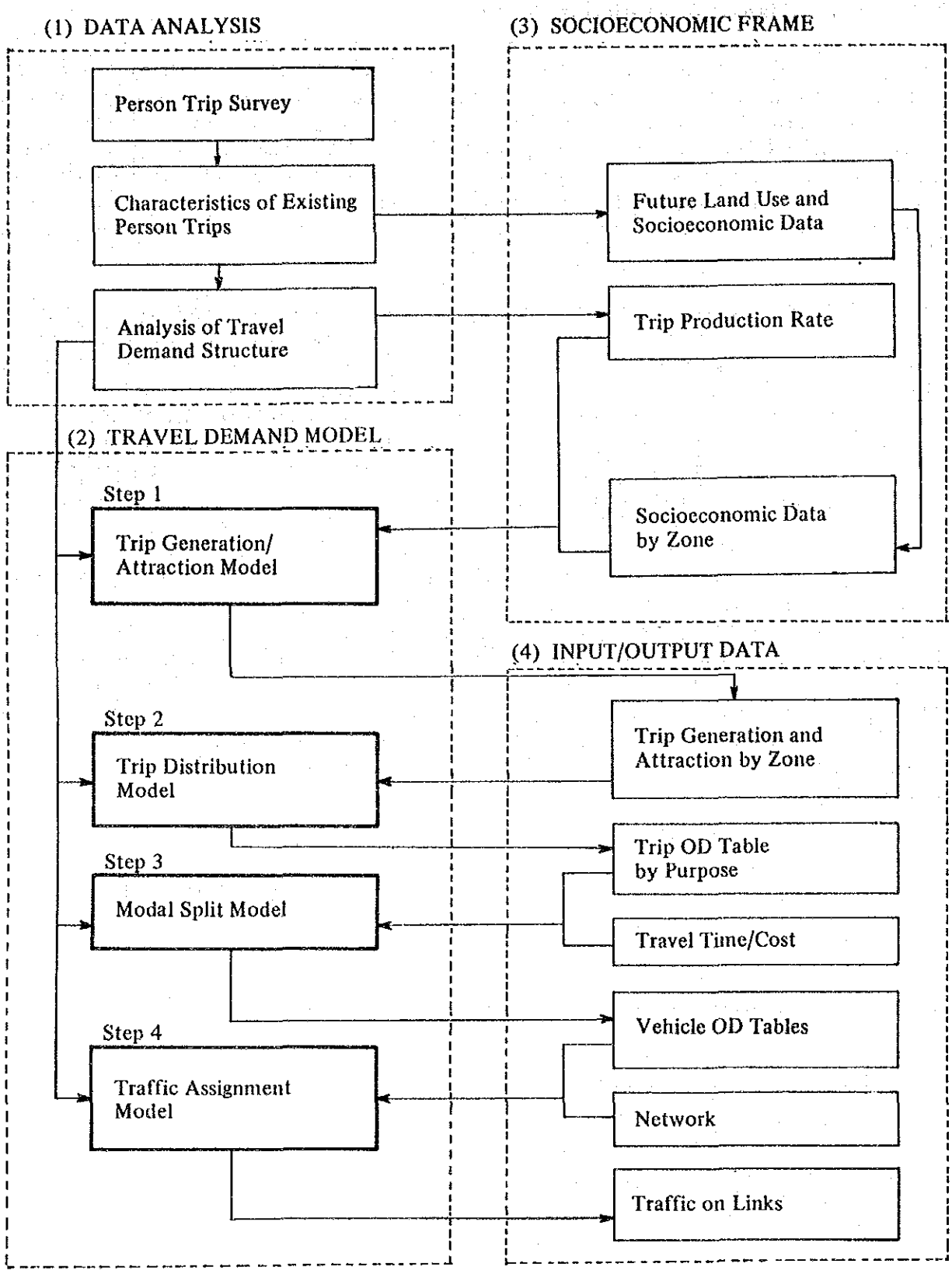


Figure 9.1-1 Flowchart of Forecasting Model

420. The classifications of motorized households, trip purposes and transportation modes are shown below;

a. Classification of Motorized Households

- Motorized household : car owning
- Non-Motorized Household : motorcycle or bicycle owning

b. Trip Purposes

- To work
- To school
- Business
- Private/Shopping
- To home

c. Classification of Modes

- Walking and Motorcycle : Walking, Motorcycle and Bicycle
- Private Mode : Car, Taxi and Truck
- Public Mode : Bus

9.1.1 Trip Generation and Attraction Model

421. This model has two steps: the first is to estimate the total trip production for an entire zone, and the second is to estimate zonal generated and attracted trips which are adjusted into agreement with the total trip production as control total.

422. Future total trip production in the Study Area was estimated by using trip production rate (number of trips per person) on the assumption that the rate is unchangeable factor in future. The total trip production was estimated by motorized and non-motorized household members due to the fact that the production rate between car owning and non-car is considerably different as shown below;

Motorized household : 2.99 trips/person/day
Non-motorized : 2.08 trips/person/day

423. Trip generation and attraction by zone are forecasted by motorized and non-motorized households and by trip purpose (exclusive of "to home") as before-mentioned. As for "to home" purpose, the trip generation is reflected as the total sum of attracted trips of other purposes exclusive of "business" purpose. On the other hand, the trip attraction is considered as the total sum of generated trips in the same manner.

424. Linear type regression models were developed to estimate trip generation and attraction. The equation is shown below;

$$Gi = a + b1*Xi1 + b2*Xi2$$
$$Aj = a + b1*Xj1 + b2*Xj2$$

where;

Gi : Generation trip from zone i
Aj : Attraction trip to zone j
Xin, Xjn : Socioeconomic data in zone i or j
a, b1, b2 : model parameters

425. Parameters of variables and zone with dummy variable are shown in Table 9.1-2.

Table 9.1-2 Parameters of Trip Generation and Attraction Model

Y / Purpose	Y=a+b1*X1+b2*X2 a	b1	b2	X1	X2	r
1) Non-Motorized						
(1) Generation						
To Work	-310.58	1.067		Employer		0.986
To School	495.29	4.294		Student-Home		0.970
Business	-466.69	0.255	3361.268	Ind-Tertial	Dummy=1	0.843
Private	-143.23	0.072	0.924	Poplation (6 y)	Ind-Tertial	0.957
(2) Attraction						
To Work	-801.84	1.137		Ind-Tertial		0.990
To School	1894.42	1.975		Student-School		0.888
Business	-630.87	0.284	3611.616	Ind-Tertial	Dummy=1	0.856
Private	-1309.48	1.344		Ind-Tertial		0.931
2) Motorized Household						
(1) Generation						
To Work	-30.43	1.376		Employer		0.966
To School	180.00	3.514		Student-Home		0.975
Business	-100.97	0.098	1204.606	Ind-Tertial	Dummy=1	0.913
Private	-369.46	0.196	0.357	Poplation (6 y)	Ind-Tertial	0.951
(2) Attraction						
To Work	-570.00	0.439		Ind-Tertial		0.972
To School	-49.39	1.092		Student-School		0.969
Business	-163.18	0.113	1232.735	Ind-Tertial	Dummy=1	0.914
Private	-485.47	0.496		Ind-Tertial		0.916

Zone with dummy varable = 1

1) Non-Motorized
Trip Generation 27, 49, 54, 56, 59, 72, 75, 82
Trip Attraction 27, 49, 54, 56, 59, 72, 75, 82

2) Motorized
Trip Generation 27, 40, 49, 56, 59, 70, 72, 82
Trip Attraction 27, 49, 56, 59, 70, 72, 82

426. Since there were some gaps on the several zones between estimated values and actual data in the "business" trip purpose, dummy variable was added in this model to improve the accuracy of estimation. As for trip generation for the "private" purpose, the correlation to explanatory variable, population (6 years old or above), is somewhat low. Tertiary employment on working place-base was added as explanatory variable.

9.1.2 Trip Distribution Model

427. Voorhees-type gravity models were developed to estimate interzonal trips by motorized/non-motorized household and by purpose. The "to home" trip was estimated in the same manner as generated and attracted "to home" trip.

(1) Interzonal Trips

$$Tij = Gi \frac{Aj \cdot Dij^{a}}{\sum Aj \cdot Dij^{a}}$$

where;

Tij : OD trips between zone i and j
Gi : Generated trips from zone i
Aj : Attracted trips to zone j
Dij : Road distance between zone i and zone j (km)
a : Parameter (refer to Table 9.1-3)

Table 9.1-3 Parameter of Trip Distribution Model

Household/Purpose	a	r^2
(1) Motorized Household		
To Work	-0.349	0.873
To School	-0.377	0.869
Business	-0.208	0.694
Private	-0.856	0.644
(2) Non-Motorized Household		
To Work	-0.577	0.898
To School	-0.923	0.737
Business	-0.131	0.767
Private	-0.541	0.715

(2) Intrazonal Trip Model

$$Tii = K \cdot Gi^{a} \cdot Ai^{b} \cdot Li^{c} \cdot Di^{d}$$

where;

Tii : OD trips inside zone i
Gi : Generated trips from zone i
Ai : Attracted trips to zone i
Li : Area of zone i (km^2)
Di : Dummy variable
K,a,b,c,d : Parameters (refer to Table 9.1-4)

Table 9.1-4 Parameters of Intrazonal Model

	Parameter					
	K	a	b	c	d	r
Motorized Households						
1) To Work	0.0484	0.6394	0.4219	0.2413	2.4174	0.876
2) To School	0.2096	0.5512	0.4363	0.2966		0.906
3) Business	7.5201	0.1100	0.1450	0.3406	2.6403	0.779
4) Private	0.0135	0.6564	0.5956	0.8473	2.6163	0.899
Non-Motorized Households						
1) To Work	0.0084	0.9124	0.3617	0.4724	2.8921	0.875
2) To School	0.0203	1.1852	0.1257	0.3860	2.7844	0.963
3) Business	2.6223	0.6126	-0.1326	0.0301	1.8267	0.861
4) Private	0.0120	0.6424	0.6704	0.1671	4.8338	0.906

428. This model pertains to the case of a model structure wherein the model parameter "b" in the "business" purpose is negative. This model, however, was applied for forecasting future figures because this can estimate figures which have a sufficient accuracy in practice by adding dummy variable.

9.1.3 Modal Split Model

429. Modal split model is used to predict the percentage of trips using each of the modes available to the given trip makers. In general, modal split model is classified into 2 types: one is known as a "trip-interchange" model in which modal split is made after "trip distribution" in the four step method. The other is known as a "trip-end" model in which modal split is performed prior to the distribution.

430. Since trip interchange model is used after trip distribution, this model can utilize the service characteristics (travel times, costs, etc.) of the alternative modes to determine the modal splits. Therefore, the trip interchange model was employed in the Study.

431. The transportation modes were classified into 3 modes: walking (walking and motorcycle), public transport (bus) and private transport (car, taxi and truck). The estimation of each transport mode was made by binary choice method shown in Figure 9.1-2. In this classification, taxi is classified into private mode due to the fact that taxi is served as private in its nature as passenger cars. Since one of main factors of modal choice is car owning or non-car owning in household from the present person trip data analysis, the estimation was made by motorized/non-motorized households and by purpose.

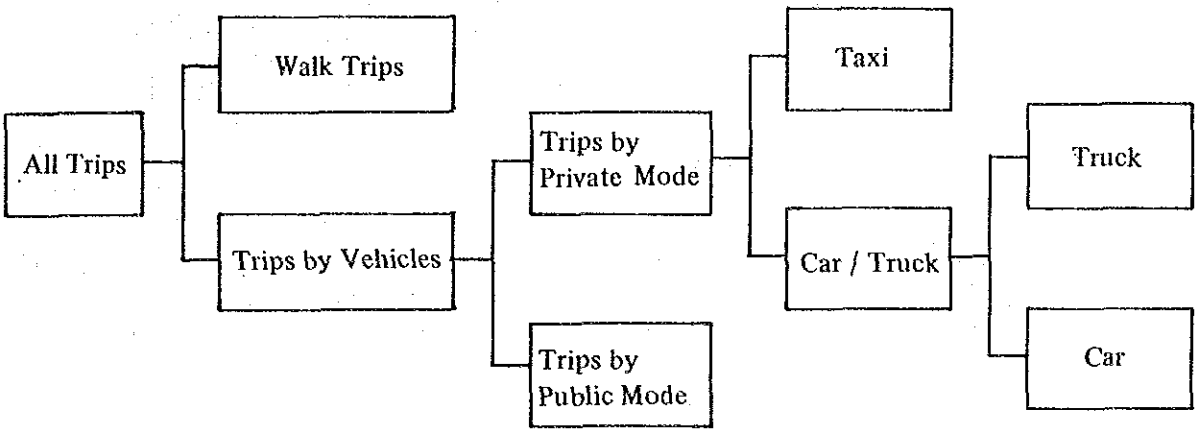


Figure 9.1-2 Procedure of Binary Choice

(1) Walking/Motorcycle (Walking) Trips

432. Since the choice of walking mode depends on walking distance, the following equation with explanatory variable of walking distance was applied to estimate walking trips.

$$Tij = K + a.\ Lij + b.\ Lij^2$$

where;

Tij : Walking OD trip ratio between zone i and j
Lij : Distance (km) between zone i and j
K,a,b : Parameters (refer to Table 9.1-5)

Table 9.1-5 Parameters of Walk Modal Split Model

Purposes	Parameters		
	K	a	b
Motorized Households			
1) To Work	0.3187	0.0166	-0.1258
2) To School	0.5151	-0.2375	0.0507
3) Business	0.3982	-0.0317	-0.0256
4) Private	0.3824	-0.0595	-0.0325
Non-Motorized Households			
1) To Work	0.7486	-0.0957	-0.1075
2) To School	0.6980	0.0530	-0.0815
3) Business	0.4339	-0.1893	0.0564
4) Private	0.4007	-0.1069	0.0074

433. This model also pertains to the case wherein the model parameter "b" in some trip purposes is positive which means the ratio of walking mode to the total modes (Tij) starts to increase at certain walking distance according to the extension of the walking distance, though the walking ratio must be decreasing. This turning point (walking distance), from decrease of the walking ratio to increase, is close to the actual limit of walking distance from survey data. Therefore, this model was applied in case when the walking distance is shorter than the turning point.

(2) Split Model for Public/Private Modes

434. The logic type model was developed to estimate the share of public transport as shown below. The time difference and cost difference were employed as the variables to express the share of public mode from vehicle trips.

$$p = 1 / (1 + \exp -(a + b.Dt + c.Dc))$$

where;

p : Share of public mode
Dt : Travel time difference (public - private in min.)
Dc : Travel cost difference (public - private in US$)
a,b,c : Parameters (refer to Table 9.1-6)

Table 9.1-6 Parameters of Public and Private Modal Split Model

Purpose	Parameter a	b	c
Motorized Households			
1) To Work	-0.4023	0.0523	0.8262
2) To School	0.7360	0.0536	1.0727
3) Business	79.2438	-121.9765	-915.9778
4) Private	-0.7921	0.3166	2.7502
Non-Motorized Households			
1) To Work	2.2708	-0.2596	-0.5760
2) To School	2.2246	-0.1175	0.9921
3) Business	1.1710	-1.0413	-7.1573
4) Private	3.0392	-0.1878	1.7737

(3) Other Split Ratios

435. The split ratio of taxi and car (including truck) applied the present ratio of trips using taxi by each zone from the Person Trip Survey data. As for the ratio of car and truck, future split ratio for an entire zone was estimated based on future trip ratio of truck to car which is estimated from future car and truck ownership.

9.1.4 Traffic Assignment

436. The last step in the four step method is the assignment of the predicted modal flows between each origin-destination pair to actual routes through the given mode's network. In this Study, traffic assignment model has two systems. One is for private vehicle such as car and truck inclusive of taxi on roads, where the private vehicle passes on minimum distance/time route chosen in this model, and the other is for public transport (bus) on fixed routes. The buses are assigned on fixed routes prepared in the model. Both assigned traffic volumes were combined together on the same road network after conducting traffic assignment separately.

437. Two bus assignment models are also developed in this Study. One is assignment model in which bus passengers are assigned on bus service routes in proportion to frequency of service. The other model assigns bus passengers on bus routes applying the minimum distance chosen from among several bus routes to connect same OD pair. The former model is applied to bus transport planning in case there are many alternative routes to connect same OD pair. The latter is employed in the planning to introduce zone bus system in which alternative routes become fewer.

(1) Average Occupancy and PCU

438. The person base trip OD tables (trip/person) by mode have to be modified into passenger car unit (trip/PCU). These OD tables were firstly modified into vehicle base unit divided by average number of passengers (occupancy) and finally, multiplied by PCU factor. The average occupancy and PCU factor used for the conversion are shown in Table 9.1-7.

Table 9.1-7 Average Occupancy and Passenger Car Unit (PCU)

Vehicle Type	Average Occupancy	PCU Factor
Passenger Car	1.80	1.00
Taxi	1.46	1.00
Truck	2.77	1.75
Bus	30.50	2.00

(2) Traffic Assignment Model for Private Mode

439. The traffic assignment model for private mode is "capacity restraint" method as shown below:

a. OD matrices are divided into following 5 lots to make the phased assignment of the traffic :1st 30%, 2nd 20%, 3rd 20%, 4th 20% and 5th 10%.
b. Minimum time-route is selected on roads.
c. The 1st lot of trips is assigned to the selected route and the number of trips passing over each link of network is counted.
d. Travel speed on each road is modified according to speed-flow curves.
e. The above four steps are iterated.

1) Assignment Conditions

The speed of vehicle to select minimum-time route is governed by the relation of traffic volume to the capacity. Hence, the speed of vehicle is determined according to speed-flow curves which are governed by the number of lanes, one-way and dual-way traffic flows, and land use conditions along road classified into urban area, rural area and unpaved road. Figure 9.1-3 and Table 9.1-8 show the speed-flow curves.

2) Estimation of Traffic Volume on Roads

As before-mentioned, car, taxi and truck are assigned in this model. On the other hand, bus is assigned under the bus assignment models. Finally, after both modes, public and private

transportation, are assigned on roads separately, both modes are combined together to estimate transport facilities.

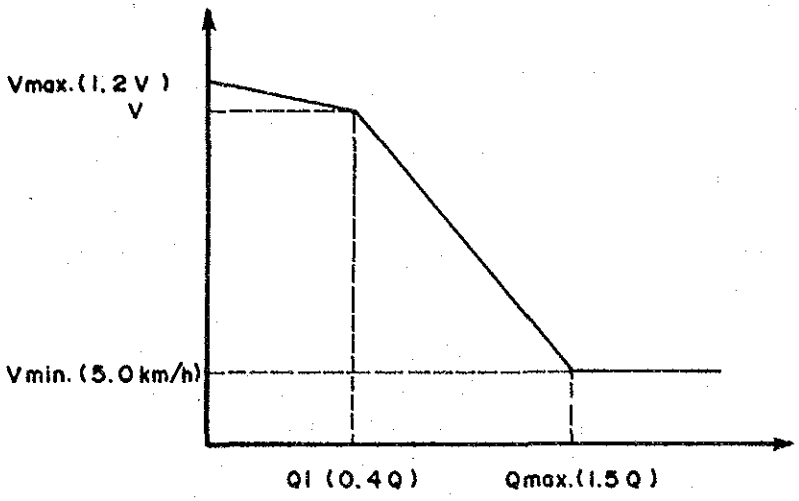


Figure 9.1-3 Typical Speed/Flow Curve

Table 9.1-8 Speed-Flow Curves

QV No.	Conditions				Speed			Capacity	
	Landuse along Road	Paved or Unpaved	No. of Lanes	1-way or Dual-way	Vmax (km/hr)	V (km/hr)	Vmin (km/hr)	Q1 (veh/day)	Qmax (veh/day)
1	1	1	8	2	96	80	5	38,400	144,000
2	1	1	6	2	96	80	5	28,800	108,000
3	1	1	4	2	96	80	5	19,200	72,000
4	1	1	3	1	96	80	5	14,400	54,000
5	1	1	2	2	96	80	5	4,800	18,000
6	1	2	2	2	36	30	5	4,800	18,000
7	1	2	1	2	36	30	5	4,800	18,000
8	2	1	8	2	72	60	5	32,000	120,000
9	2	1	6	2	72	60	5	24,000	90,000
10	2	1	4	1	72	60	5	16,000	60,000
11	2	1	4	2	72	60	5	16,000	60,000
12	2	1	3	2	72	60	5	12,000	45,000
13	2	1	3	1	72	60	5	12,000	45,000
14	2	1	2	2	72	60	5	4,000	15,000
15	2	1	2	1	72	60	5	8,000	30,000
16	2	1	1	1	72	60	5	4,000	15,000
17	2	2	6	2	24	20	5	24,000	90,000
18	2	2	4	2	24	20	5	16,000	60,000
19	2	2	2	2	24	20	5	4,000	15,000
20	3	1	4	1	48	40	5	12,800	48,000
21	3	1	4	2	48	40	5	12,800	48,000
22	3	1	3	1	48	40	5	9,600	36,000
23	3	1	2	1	48	40	5	6,400	24,000
24	3	1	2	2	48	40	5	3,200	12,000
25	3	1	1	1	48	40	5	3,200	12,000
26	2	1	1	2	72	60	5	2,000	7,500
27	3	1	1	2	48	40	5	1,600	6,000

Conditions of Q-V Data

1) Landuse; 1 : Rural
2 : Urban
3 : Comercial

2) Road Surface; 1 : Paved
2 : Unpaved

3) Direction; 1 : One-way
2 : Dual-way

(3) Traffic Assignment Model for Public Mode (Bus Transportation)

440. Two bus assignment models are considered:

a. Assigning on bus routes relating to frequency of service (Model-I)
b. Assigning on minimum distance from among several bus routes (Model-II)

1) Assigning based on frequency of service (Model-I)

441. In the bus assignment model (Model-I), bus passengers are assigned on bus routes according to priority of number of bus transfers in small order by OD pair. In case of finding out a certain route connecting origin-destination with 0-transfer, passengers are assigned on its route. If bus transfers occur, passengers are assigned on alternative routes in proportion to frequency of service taking into account priority of number of bus transfers.

442. Method of Model-I is outlined as follows;

a. Number of Transfers : 0
- assigning on selected bus route.

b. Number of Transfers : 1 or more
- finding several routes with 1-transfer for a certain OD pair
- assigning on several routes in proportion to frequency of service

in case of 2- or more-transfers, the above 2-steps (b-c) are iterated under the same number of transfers (1 or more)

2) Assigning on minimum distance route (Model-II)

443. Minimum bus route from among several alternative routes under the same number of transfers by OD pair is chosen and bus passengers are assigned on this route. This assignment system introduced the concept of traffic assignment model for private mode in which OD table is divided into several lots and assigned route is determined by each lot according to equilibrium equations between speed and capacity. In this Model-II, assigned bus route is determined by each lot according to frequency of service instead of speed-flow curve. When the frequency is exceeded by assigned number of buses, this bus route is not chosen in next lot.

444. Method of Model-II is outlined as follows;

a. OD matrices are divided into the following 3 lots to make the phased assignment of the traffic: 1st 50%, 2nd 30% and 3rd 20%.

b. Minimum distance route is selected on the following assumption:

- in case of 0-transfer
  Selecting minimum distance bus route from among several alternative routes to link each OD pair with 0-transfer.
- in case of 1 or more-transfers
- Selecting minimum distance bus route from among several alternatives under the same number of transfers.

c. The 1st lot of trips is assigned to the selected bus route and the number of trips incrementally loaded onto bus network is counted.

d. Frequency of service by each bus route (input data) is compared to assigned number of buses derived from the assigned number of passengers. When the number of buses exceeds the frequency, this bus route is not chosen in next lot.

e. The above 4 steps are iterated.

9.2 Estimation of Future Motorized Households

445. Since the travel demand model is structured by motorized and non-motorized households as before mentioned, number of motorized households in future must be estimated. The procedure of estimation is shown below;

(1) Estimation of total number of motorized households
(2) Estimation of motorized households by zone

446. The first step (1) is to estimate the total number of motorized households in the Study Area and then, it is broken down into traffic zones in the second step (2).

9.2.1 Total Number of Motorized Households

447. There is a close relationship between car ownership and household income from analysis of the Person Trip Survey data (refer to Figure 2.5-2). This relationship was used for the estimation of total number of motorized households, i.e., car owning households was estimated by inputting both future estimated income distribution and number of households. In this process, forecasting of two or more vehicle owning households is indispensable in the estimation of motorized households because they are sizable in number. The multi-car owning was also estimated in the same manner as one-car owning by using relationship shown in Figure 9.2-1. These estimated motorized households were controlled by the future total number of cars.

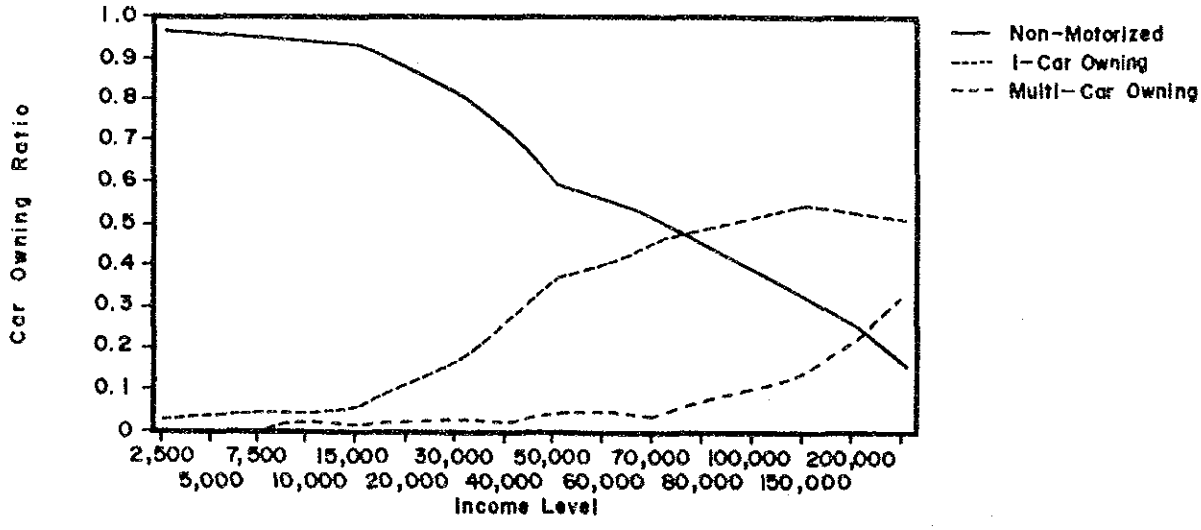


Figure 9.2-1 Motorized Household Ratio and Average Household Income

448. The estimated figures are shown in Table 9.2-1. The number of motorized households is approximately 120 thousands, equivalent to 0.23 per household, in 2010. This is a rise of 2.1. Non-motorized households are somewhat lower (1.6) in growth rate.

Table 9.2-1 Total Number of Motorized Households
(unit:household)

Types	1990	2010	2010/1990
(1) Non-Motorized Households	246,397	397,571	1.614
(2) Motorized Households	56,044	119,204	2.127
(3) Car Ownership (/household)	0.185	0.231	

9.2.2 Motorized Households by Zone

449. Both average income and car ownership by zone have a close relation between each other as determined from the analysis of the Person Trip Survey data. In this relationship, zone with high income level is high in car ownership rate while low car owning is in low income zone. This relationship was used for estimating the motorized households by each zone, i.e., the zonal average household income was employed as explanatory variable. This was adjusted so that the total sum of motorized households of all zones was equivalent to the total number of motorized households.

450. The estimated zonal motorized households are shown in Figure 9.2-2 which shows the comparison between figures in 1990 and 2010. As seen, the number of motorized households is maintained at the same level in the central area between 1990 and 2010, while the figures in sub-urban area (integrated zone of Guanabara, Bengui, Icoaraci, Cidade Nova, J. Seffer and Ananindeua) show a sharp increase.

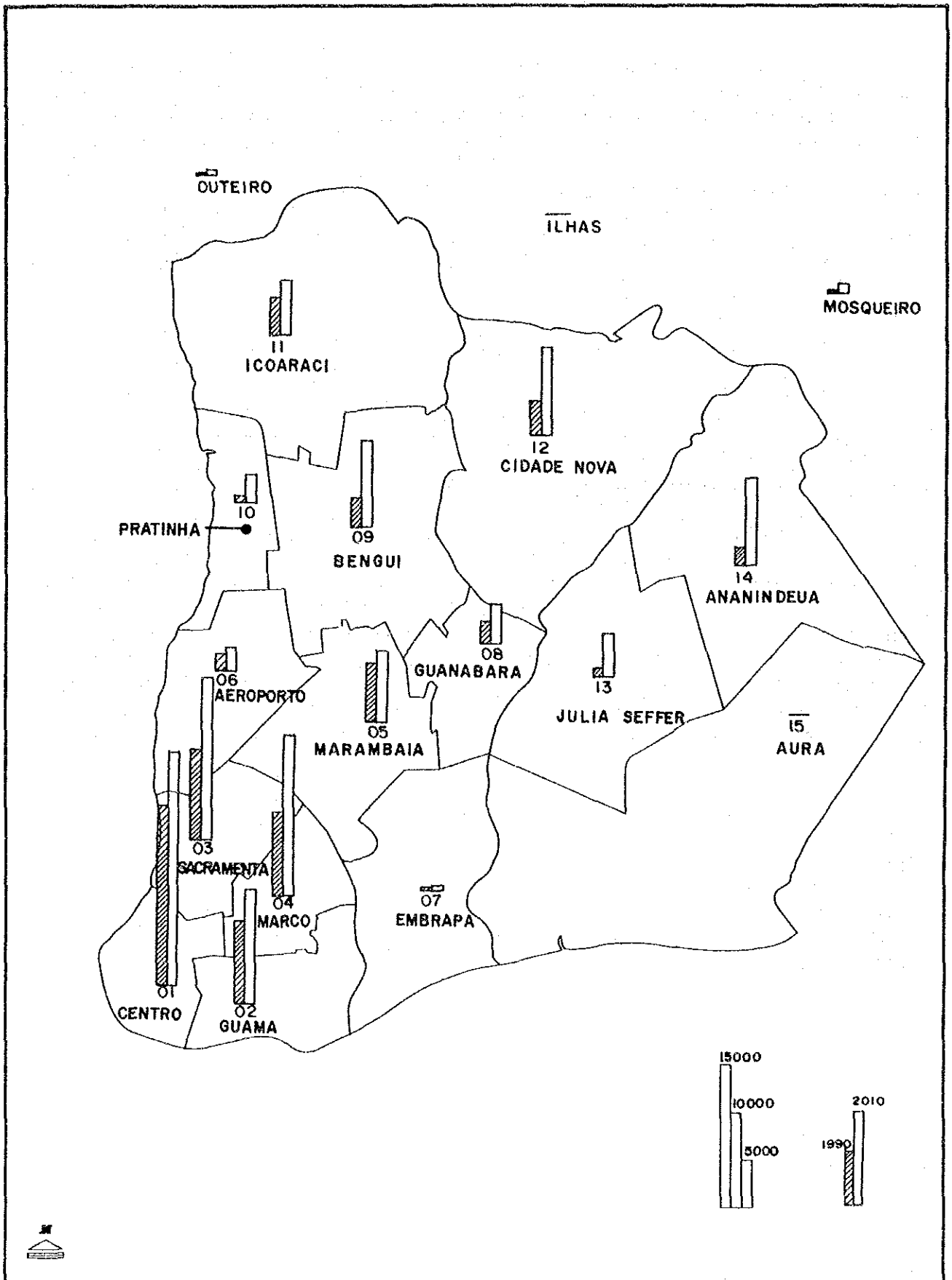


Figure 9.2-2 Estimated Motorized Households by Zone

9.3 Projection of Travel Demand

9.3.1 Total Number of Trips

451. The total number of trips per day in the Study Area in 2010 is approximately 5.13 millions, of which 5.03 million trips, equivalent to 98 % to the total, are within the Study Area, and 100 thousand trips (2 %) are for trips which has the trip origin or destination in the outside of the Study Area. The trip increase ratio of the year 2010 to 1990 is approximately 1.78, in contrast to 1.71 of the population growth ratio. Summary of trip flows in 1990 and 2010 is shown in Figure 9.3-1, and summary of socioeconomic and travel demand is shown in Table 9.3-1.

Table 9.3-1 Summary of Socioeconomics 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

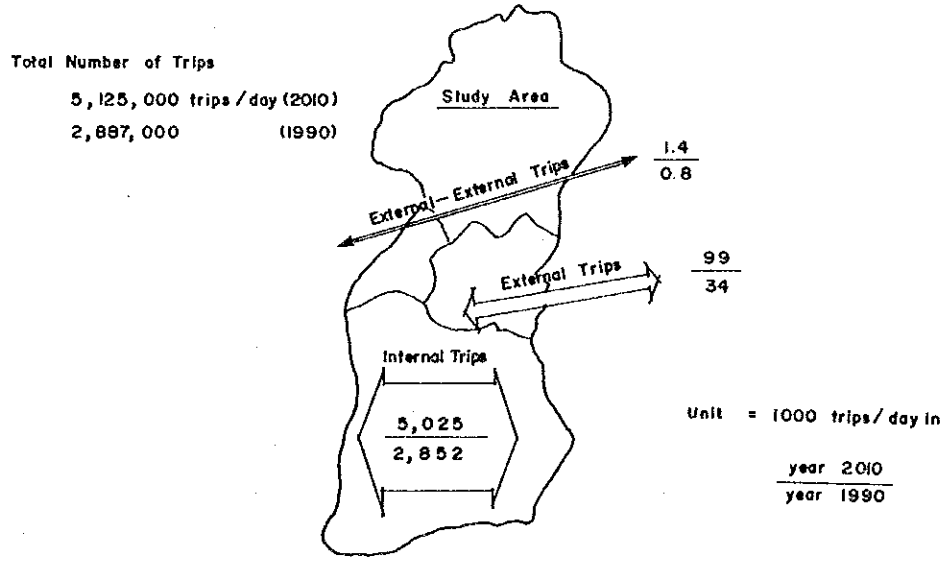


Figure 9.3-1 Summary of Trip Flow in 1990 and 2010

9.3.2 Trips by Purpose

452. Numbers of trips by purpose in the years 1990 and 2010 are shown in Figure 9.3-2. The increase ratios of trips by purpose during two decades range from 1.74 for "private" purpose to 2.05 for "business". As for the "to work" purpose, the figure shows a rise of 1.80. The future composition of "private" is highest (20.6%) exclusive of "to home", followed by 18.6% for "to work", 15.0% for "to school" and 5.5% for "business". The composition rates of "to work" and "business" in 2010 are 0.7 and 0.2% higher than that of 1990, respectively, while "to school" and "private" are 0.2 and 0.5% lower.

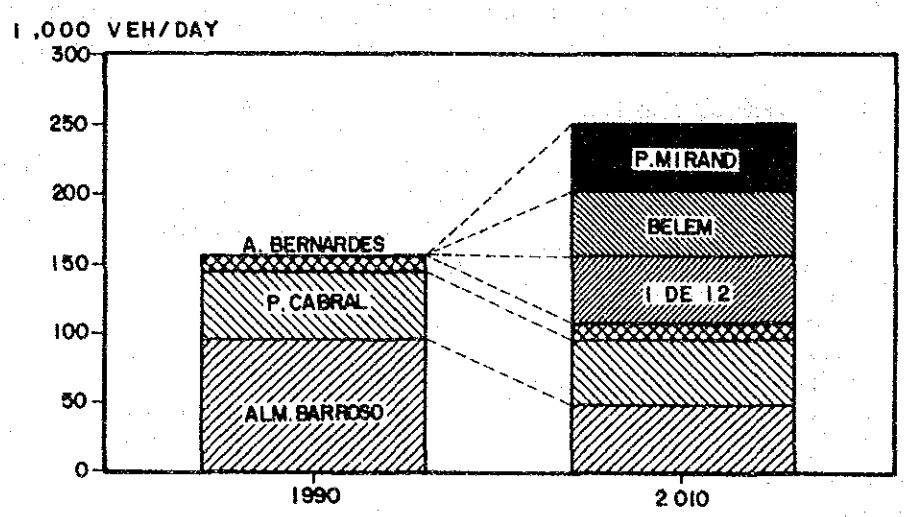


Figure 9.3-2 Trip Comparison by Purpose in 1990 and 2010

9.4 Trip Generation and Attraction

453. Estimated trip generation and attraction in the year 2010 according to the integrated zone are shown in Table 9.4-1 and Figure 9.4-1 shows comparison between the figures in 1990 and 2010. As seen, the increase rate of trip generation between 1990 and 2010 in the sub-urban area becomes dramatically high (2.0-5.0), while central area is somewhat high (1.2-1.8). On the other hand, population growth in the sub-urban area ranges from 1.5 to 5.5 and 1.0-1.2 for central area. It is indicated that the trip generation increases with relation to population growth.

454. As for trip attraction, the increase rate of central area is somewhat higher (1.3-1.9), in contrast to 1.2-1.8 of the generation. In the sub-urban area, the figures are slightly lower (1.5-4.5), comparing with the generation (2.0-5.0). This is because work-place/school-place base population (employment and enrollment) is substantially concentrated into the central area, comparing with the distribution of population.

455. Figure 9.4-2 shows the trip generation and attraction by purpose in 1990 and 2010 in which "to home" trips are excluded to clearly show the characteristics of generation and attraction. Figure 9.4-3 also shows the generation and attraction of "to work" purpose in which size of circle indicates the volume of generation or attraction in 2010 superimposed on that in 1990. As seen, trip generation by zone both in 1990 and 2010 is similar in its composition, i.e., the Centro (Zone No.1) with high percentage of "private" purpose has relatively low share of "to work" purpose, while "to work" purpose is predominant in the other urban and sub-urban area. In 2010, the "to work" trip ratio in the sub-urban area (Integrated Zone of Bengui, Pratinha, Icoaraci, Cidade Nova, J. Seffer and Ananindeua) rises from approximately 35% to 40% according to high population growth.

456. On the other hand, although the characteristics of trip attraction by purpose in 1990 and 2010 are also similar by each zone, the percentage of "to work" purpose in the suburban area (Zone of Cidade Nova and J. Seffer) increases from 20% to 30%. These zones have also high employment growth (work-place base) whose figures climb to 4.5 (Zone of Cidade Nova) and 7.5 (Zone of J. Seffer), respectively.

Table 9.4-1 Trip Generation and Attraction (2010)

Generation

Zone Blk	To Work	To School	Business	Private	To Home	Total
1	70,688	78,953	55,103	206,306	470,787	881,837
2	95,555	81,131	22,041	91,398	188,904	479,029
3	97,352	90,411	37,850	149,651	295,021	670,285
4	64,265	68,270	39,008	149,735	311,893	633,171
5	69,484	68,157	14,999	56,144	104,111	312,895
6	28,713	16,361	3,928	19,772	33,632	102,406
7	1,135	831	2,136	4,350	9,596	18,048
8	39,966	29,062	7,893	36,266	61,799	174,986
9	119,268	91,505	14,598	66,597	104,189	396,157
10	22,988	16,732	6,685	27,847	48,663	122,915
11	61,950	28,308	18,522	45,868	81,386	236,034
12	131,963	92,405	12,785	70,577	104,042	411,772
13	59,342	46,777	9,797	33,543	51,218	200,677
14	79,613	49,828	20,420	75,243	142,689	367,793
15	177	749	637	1,271	2,428	5,262
16	2,397	2,035	1,509	5,506	10,142	21,589
17	0	0	0	0	0	0
18	5,047	6,535	2,804	8,262	19,489	42,137
19	2,771	1,303	12,442	6,465	25,903	48,884
Total	952,674	769,353	283,157	1,054,801	2,065,892	5,125,877

Attraction

Zone Blk	To Work	To School	Business	Private	To Home	Total
1	206,021	213,217	57,558	229,922	266,261	972,979
2	84,148	81,185	22,316	93,128	198,544	479,321
3	142,072	86,212	39,054	157,770	251,638	676,746
4	146,711	105,036	39,912	163,069	210,676	665,404
5	43,624	53,868	14,830	49,231	140,940	302,493
6	16,412	9,991	3,737	17,513	48,763	96,416
7	4,211	4,316	991	4,675	4,839	19,032
8	30,269	16,913	7,708	33,278	78,437	166,605
9	47,269	43,444	14,070	51,701	204,499	360,983
10	25,576	6,580	6,580	28,270	51,234	118,240
11	38,585	27,840	18,235	40,000	102,764	227,424
12	49,965	31,983	12,732	54,884	217,810	367,374
13	22,313	23,787	9,620	24,938	102,565	183,223
14	66,322	49,215	20,485	74,706	154,789	365,517
15	1,193	2	624	1,271	1,239	4,329
16	4,978	2,213	1,355	5,404	7,189	21,139
17	0	0	0	0	0	0
18	8,315	11,010	2,873	8,749	14,622	45,569
19	14,690	2,541	10,477	16,292	9,083	53,083
Total	952,674	769,353	283,157	1,054,801	2,065,892	5,125,877

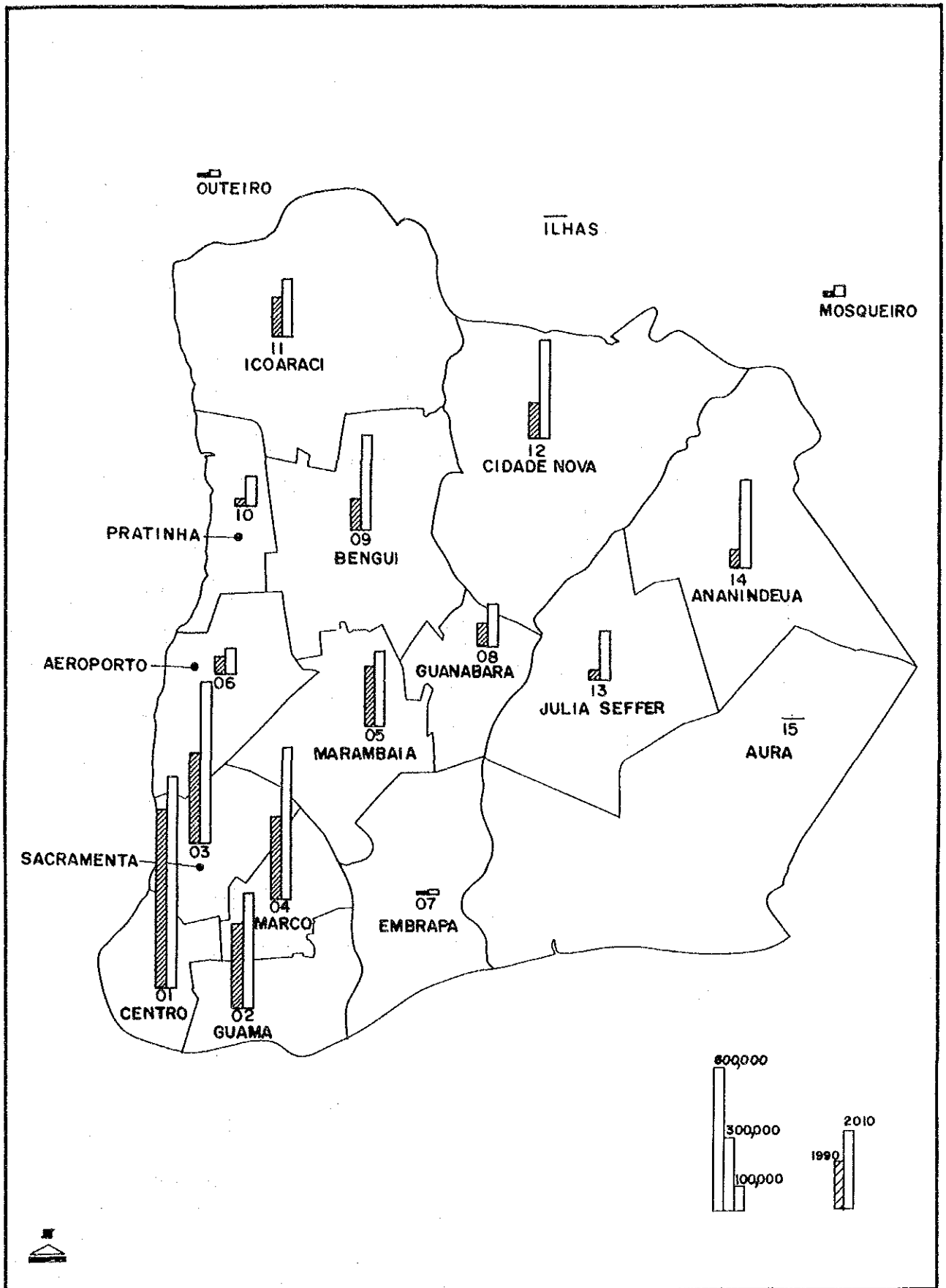


Figure 9.4-1(A) Trip Generation (1990/2010)

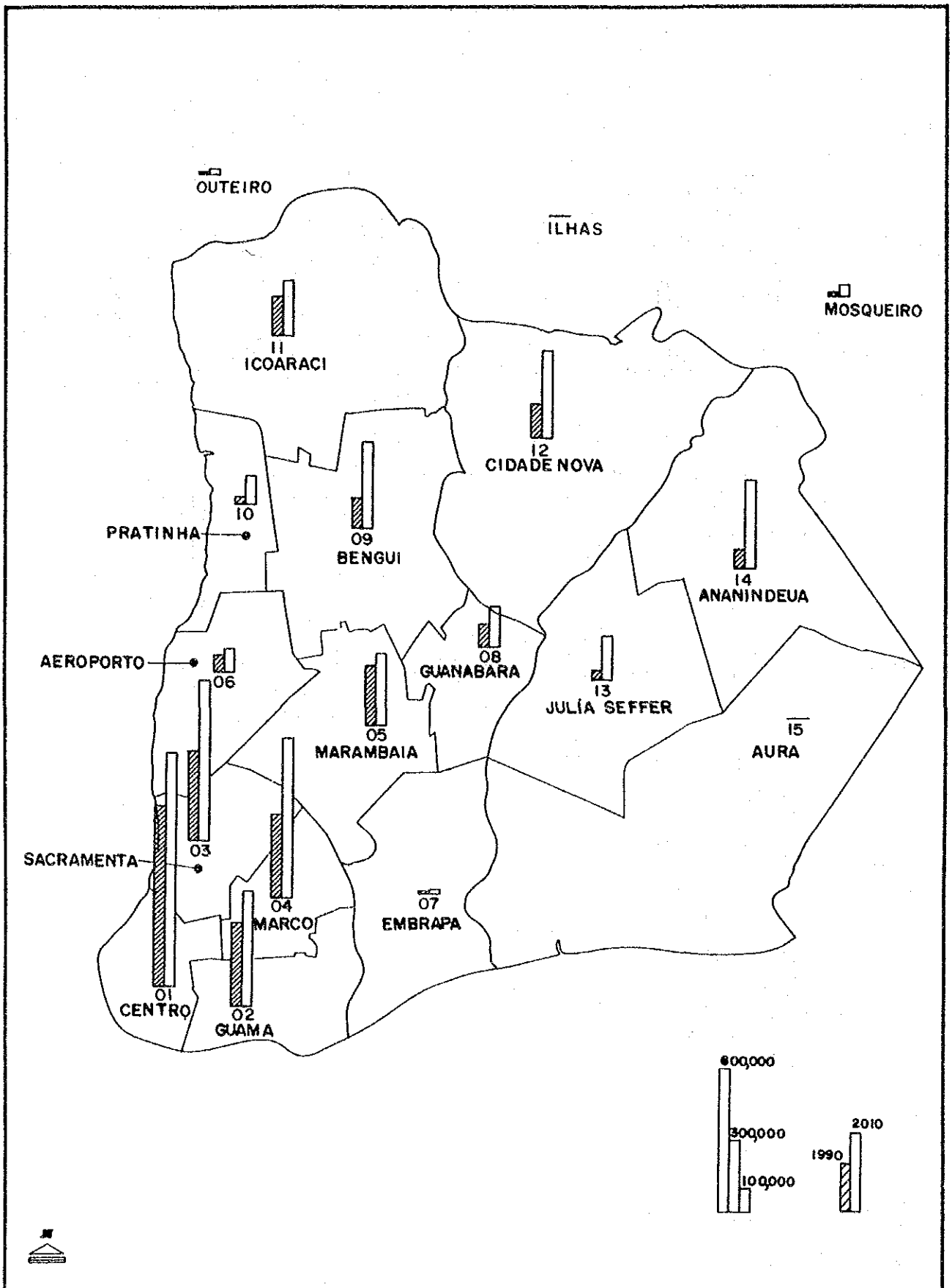
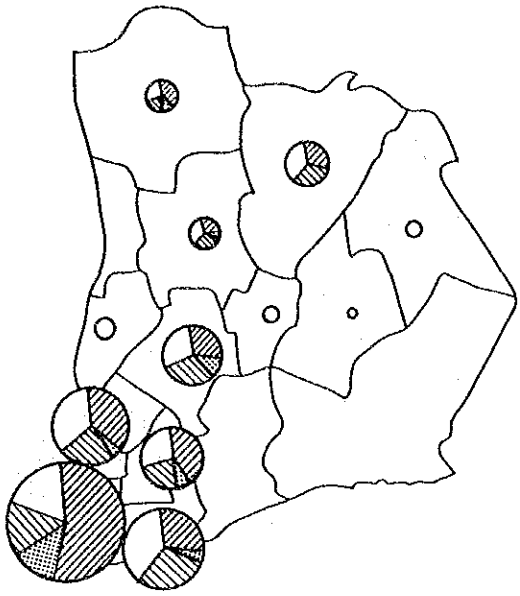
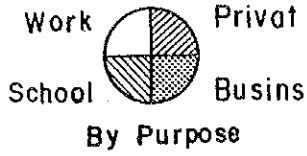
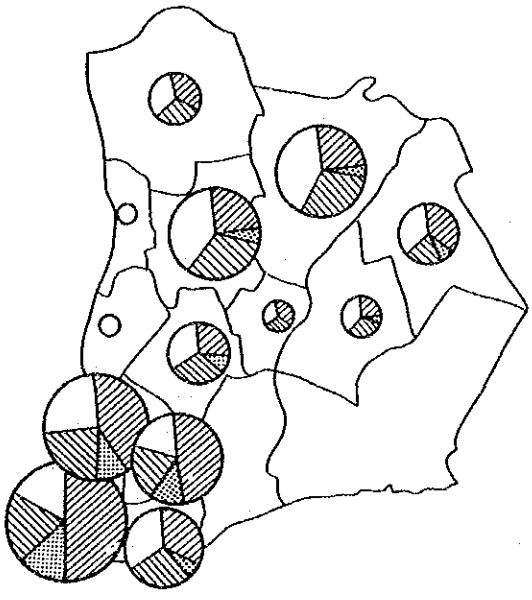


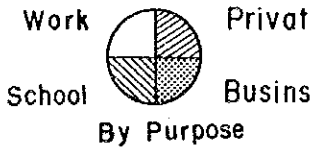
Figure 9.4-1(B) Trip Attraction (1990/2010)





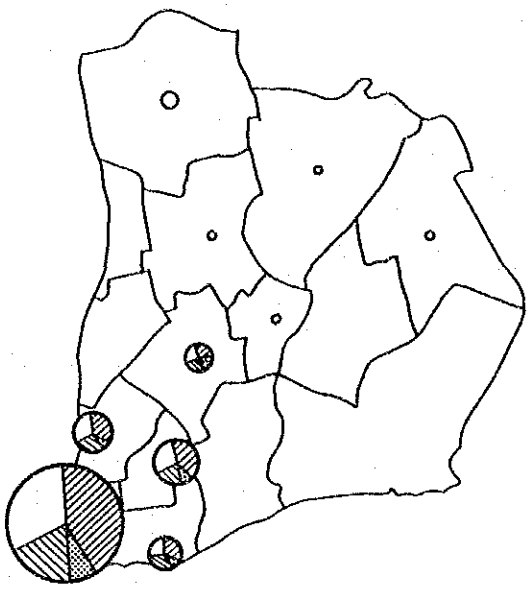
Trip Generation (1990)

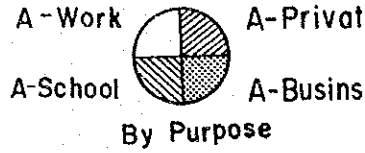




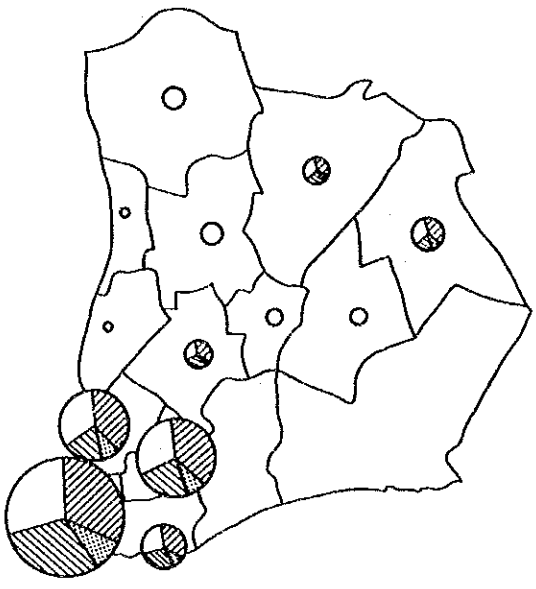
Trip Generation (2010)

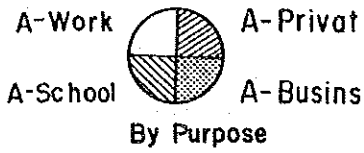
Figure 9.4-2(A) Trip Generation by Purpose (1990/2010)





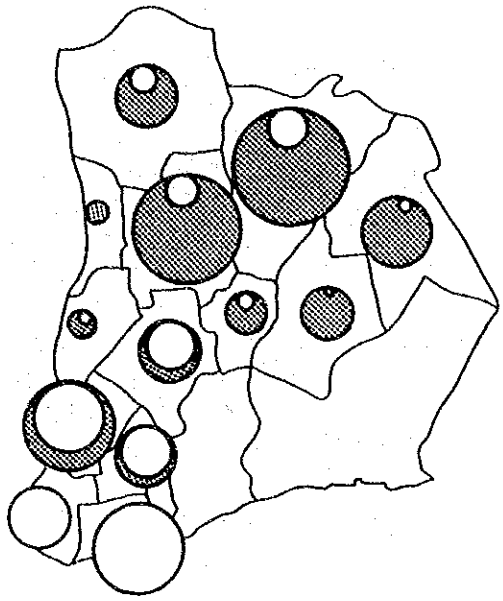
Trip Attraction (1990)

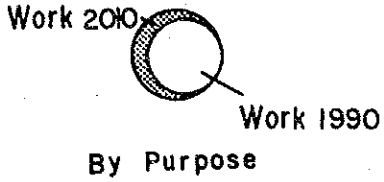




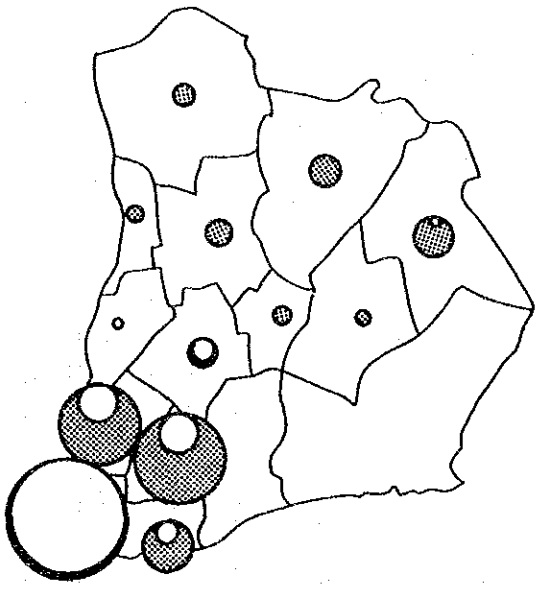
Trip Attraction (2010)

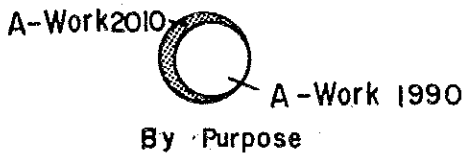
Figure 9.4-2(B) Trip Generation by Purpose (1990/2010)





Trip Generation (1990/2010)





Trip Attraction (1990/2010)

Figure 9.4-3 Trip Generation and Attraction (To Work, 1990/2010)

9.5 Trip Distribution

9.5.1 Trip Distribution by Purpose

457. The trip OD table for all purpose and all mode in 2010 is shown in Table 9.5-1 which is integrated into 20 zones. Figure 9.5-1 illustrates the desire lines for interzonal trips in 1990 and 2010. As seen, heavy trip flows in 2010 are between the central area (Integrated Zone of Centro, Guama, Sacramenta and Marco) and its surrounding suburban area (Zone of Marambaia, Bengui, Pratinha, Icoaraci, Cidade Nova, J. Seffer and Ananindeua). 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.

Table 9.5-1 OD Table in 2010

Int. Zone	Name	1	2	3	4	5	6	7	8	9	10
1	Centro	346,135	81,625	109,097	86,469	35,593	12,682	1,936	15,987	46,026	10,431
2	Guama	92,667	170,774	46,848	56,452	17,556	5,771	1,128	7,620	16,305	2,973
3	Sacramenta	121,486	48,298	234,817	93,813	29,148	11,869	1,909	10,596	25,403	10,288
4	Marco	92,697	50,311	93,308	199,573	40,204	8,656	2,058	14,988	31,506	6,601
5	Marambaia	44,831	18,283	30,301	45,431	86,959	6,437	2,645	10,236	20,198	3,297
6	Aeroporto	15,243	6,409	12,864	10,230	6,320	28,661	297	1,676	6,023	1,467
7	Embrapa	2,224	1,306	1,586	1,950	2,184	212	3,417	493	924	177
8	Guanabara	20,613	8,643	12,598	17,862	11,137	1,800	585	50,145	9,789	1,763
9	Benqui	59,310	20,438	29,717	38,158	22,893	5,550	1,303	10,400	143,222	8,492
10	Pratinha	12,401	3,582	10,607	6,824	3,665	1,609	251	1,643	9,091	58,598
11	Icoaraci	29,904	9,069	16,055	18,155	8,293	3,354	490	6,378	14,569	5,735
12	Cidade Nova	50,810	18,629	27,747	36,657	14,811	3,761	1,225	18,786	15,567	3,821
13	Julia Seffer	30,073	9,004	13,368	17,113	8,057	1,991	668	5,677	7,223	1,701
14	Ananindeua	41,346	25,365	22,193	24,981	13,179	2,770	841	7,371	11,561	2,252
15	Aura	277	151	151	152	121	36	4	74	201	24
16	Outeiro	1,079	5,128	760	841	486	166	17	221	988	167
17	Ilhas	0	0	0	0	0	0	0	0	0	0
18	Mosqueiro	3,762	843	1,116	1,365	678	228	27	379	1,156	196
19	Exterior(1)	1,633	319	415	298	184	114	1	3,315	296	79
20	Exterior(2)	6,488	1,144	13,198	9,080	1,025	749	230	620	935	178
Total		972,979	479,321	676,746	665,404	302,493	96,416	19,032	166,605	360,983	118,240

Int. Zone	Name	11	12	13	14	15	16	17	18	19	20	Total
1	Centro	27,927	35,570	23,784	37,194	90	872	0	2,745	1,511	6,163	881,837
2	Guama	8,018	13,694	7,485	23,731	84	4,344	0	1,149	561	1,869	479,029
3	Sacramenta	13,457	21,343	10,943	21,986	86	729	0	1,329	531	12,254	670,285
4	Marco	16,045	30,654	14,616	21,999	71	633	0	1,231	452	7,558	633,171
5	Marambaia	7,673	12,021	7,558	13,372	77	520	0	1,081	278	1,697	312,895
6	Aeroporto	3,847	3,232	1,759	2,997	25	185	0	321	125	725	102,406
7	Embrapa	411	845	1,078	815	0	12	0	40	20	354	18,048
8	Guanabara	4,902	17,405	5,196	8,304	54	281	0	625	2,327	957	174,986
9	Benqui	14,907	14,184	7,584	14,021	135	1,192	0	1,970	480	2,201	396,157
10	Pratinha	6,160	3,257	1,619	2,528	12	219	0	341	71	437	122,915
11	Icoaraci	100,167	8,030	3,814	8,460	59	850	0	806	282	1,564	236,034
12	Cidade Nova	9,050	163,507	10,020	29,666	199	1,029	0	2,519	527	3,441	411,772
13	Julia Seffer	4,491	9,288	70,660	18,095	96	418	0	1,106	212	1,436	200,677
14	Ananindeua	7,886	29,279	14,835	158,815	171	568	0	1,580	326	2,474	367,793
15	Aura	101	261	153	379	3,165	2	0	10	0	0	5,262
16	Outeiro	840	691	328	537	1	9,208	0	52	6	73	21,589
17	Ilhas	0	0	0	0	0	0	0	0	0	0	0
18	Mosqueiro	576	1,288	627	1,069	4	41	0	28,053	29	700	42,137
19	Exterior(1)	141	313	169	169	0	4	0	10	26	175	7,661
20	Exterior(2)	825	2,512	995	1,380	0	32	0	601	336	895	41,223
Total		227,424	367,374	183,223	365,517	4,329	21,139	0	45,569	8,110	44,973	5,125,877

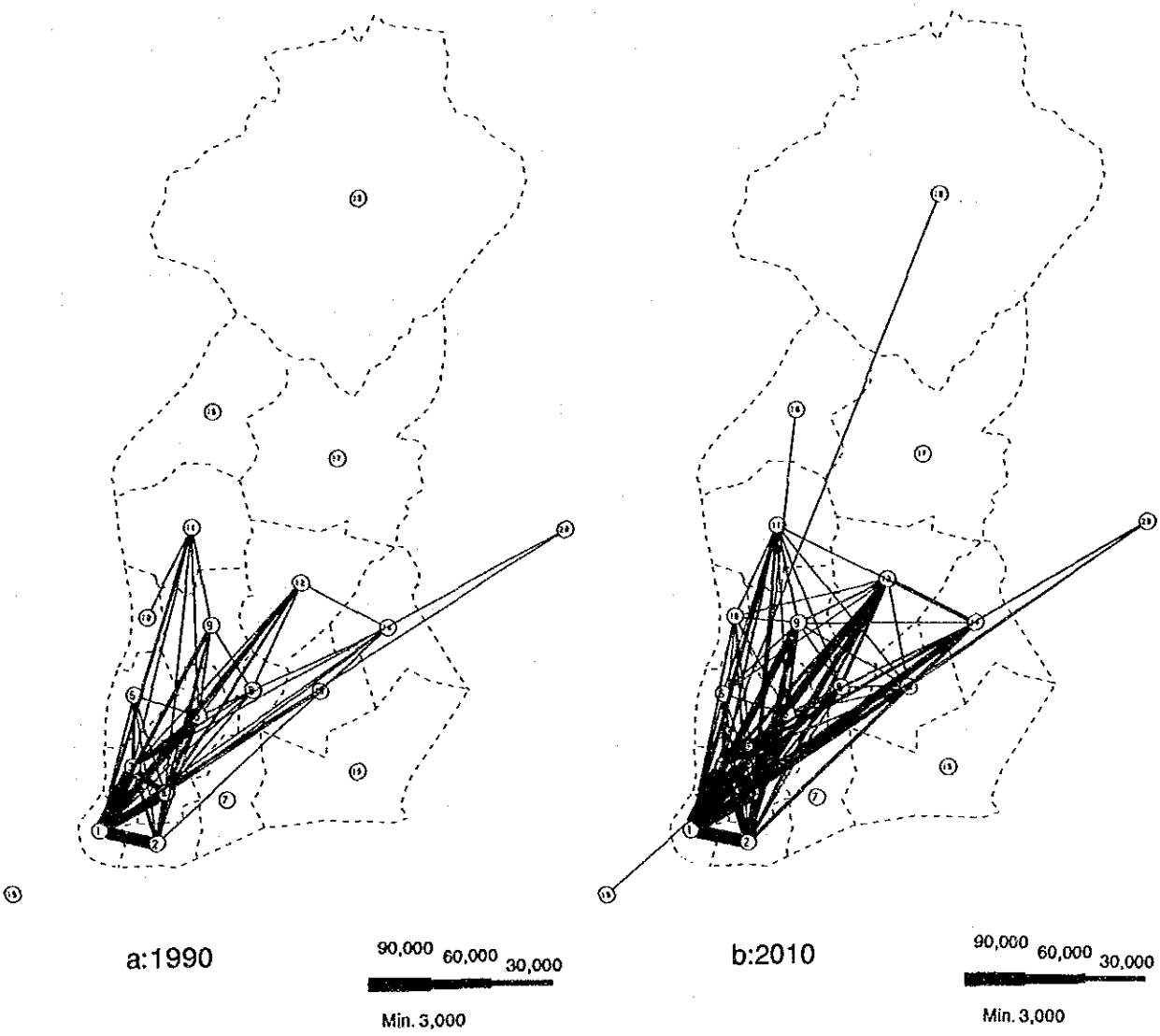


Figure 9.5-1 Trip Desire Line

458. The concentration degree into the central area, especially Zone of Centro, from other areas is analyzed and shown in Figure 9.5-2. The concentration degree is defined as the ratio of OD trips linked Zone of Centro and certain zone to trip generation of the certain zone. The average concentration ratio defined above decreases from 0.26 in 1990 to 0.19 in 2010, a decline by roughly 30%. The decrease of concentration occurs on every zone exclusive of Zones of Ananindeua and Aura. It seems to indicate that the potential of socioeconomic activities in the integrated Zone of Centro is somewhat lower in the future.

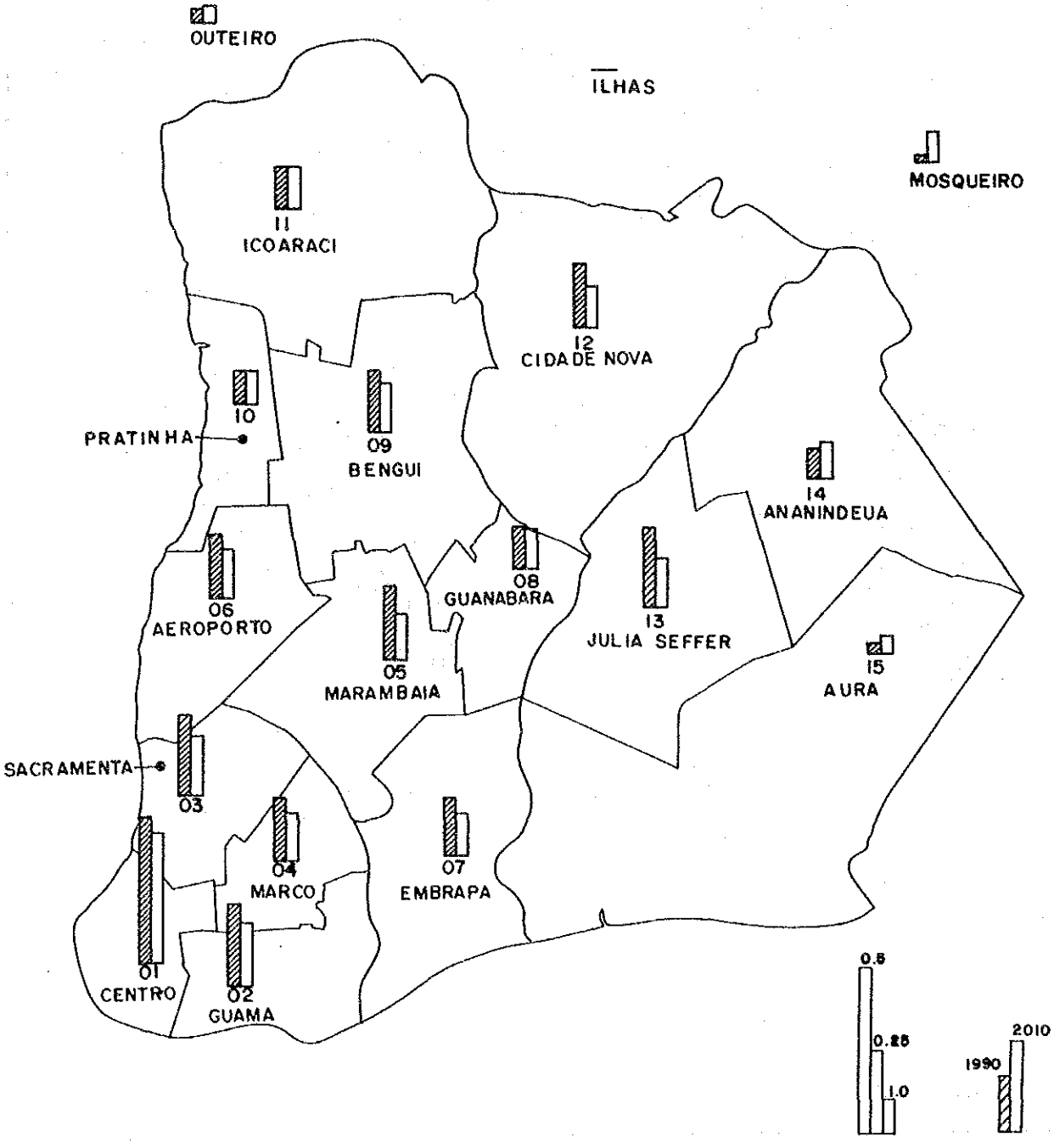


Figure 9.5-2 Trip Generation Rate into Centro

9.5.2 Trip Length Distribution

459. According to expansion of urban area in the future land use planning, trip length increases in future. The trip length distribution in 1990 and 2010 is compared in Figure 9.5-3. The average trip length in 2010 is 12.46 km, in contrast to 9.13 km in 1990. Approximately 85 % of the total trips in 1990 have trip length within 14 km. In 2010 this figure is expected to be 18 km, an increase of roughly 4 km.

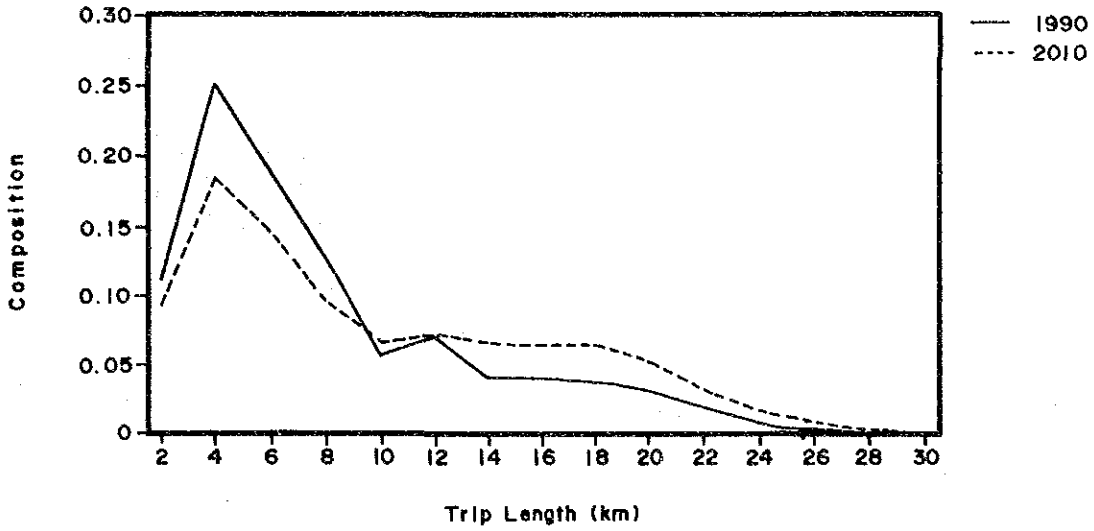


Figure 9.5-3 Trip Length Distribution

9.6 Modal Split

460. Number of trips by mode which is classified into 3 modes, Walking, Public and Private Transport, is shown in Table 9.6-1. As for increase ratio by mode between 1990 and 2010 in person trip base, the public and private modes are approximately 2.1 and 1.9, respectively. The walking mode is somewhat lower (1.2) and is below the average of the total. The modal share of public in person trip base is 62% (3.2 million trips) in 2010, in contrast to 54% (1.5 millions) in 1990. The private mode rises from 17% (500 thousand trips) in 1990 to 18% (916 thousands) in 2010.

461. Table 9.6-2 shows the number of vehicle trips converted into passenger car unit (PCU). The modal share of private mode in pcu base is 76% in 1990, and the figure for 2010 is only 3% lower (73%). On the other hand, the public mode is somewhat increased from 24% in 1990 to 27% in 2010.

Table 9.6-1 Modal Share of Person Trips (unit; person per 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

Table 9.6-2 Modal Share of Vehicle Trips (unit; pcu)

Mode	1990		2010		2010/1990
	No. of Trip	Comp.	No. of Trip	Comp.	
Public	99,376	0.24	207,586	0.27	2.09
Private	318,296	0.76	572,096	0.73	1.80
Total	417,672	1.00	779,682	1.00	1.87

9.7 Traffic Demand on Spider Network

462. Traffic assignment on spider network was made to disclose traffic demand on major corridors. The traffic demand on spider network is shown in Figure 9.7-1. At present heavy traffic flows are observed in both corridors; Av. Almirante Barroso:BR-316 and Rd. Arthur Bernardes. In 2010, the traffic demands of two

Figure 9.7-1(A) Traffic Demand on Spider Network (1990)

corridors are considerably higher, especially Av. Almirante Barroso is 2.2 times while for Rd. Arthur Bernardes it is 1.4. Traffic movement in future in the Study Area concentrated on Av. Almirante Barroso and BR-316 will impact on the future land use planning and its socioeconomic framework (refer to Figures 9.7-1(A) and 9.7-1(B)).

Figure 9.7-1(B) Traffic Demand on Spider Network (2010)

9.8. Traffic Demand in Case of Land Use and Car Ownership Alternatives

9.8.1 Land Use Alternative Case

463. Using the socioeconomic indices in Table 8.3-16, the future traffic demand is forecasted. The total trip number in the Study Area becomes 5,129,762 as shown in Table 9.8-1.

Table 9.8-1 Future Modal Share of Trip

Mode	1990	2010	2010(base case)
walking	851,016	1,085,889	1,043,558
car	366,190	790,902	726,906
taxi	38,831	49,817	53,092
truck	86,446	145,434	136,287
bus	1,544,975	3,057,720	3,166,034
Total	2,887,458	5,129,762	5,125,877

464. Total number of trips is almost same between base case and land use alternative. Trips by bus and taxi are decreased a little and those by other modes are increased by several percent.

465. The change of trip generation and attraction by Integrated zone are shown in Figure 9.8-1 and 9.8-2, respectively. Due to the increased distribution of employment opportunities and educational facilities in suburban zones, the number of trip generation and attraction increases in suburban zones and those in central area will decrease considerably.

466. The reduction of trip generation in the central area, in spite of increased distribution of population, is mainly due to the lower distribution of employment opportunity which greatly contributes to the generation of private and other purpose trips.

467. The change of trip distribution is shown in Figure 9.8-3. The trips between the central area and suburban area decrease by about 10 percent. On the other hand, the trips between suburban zones increase by some 30 percent reflecting the growth of trip generation and attraction in the Area.

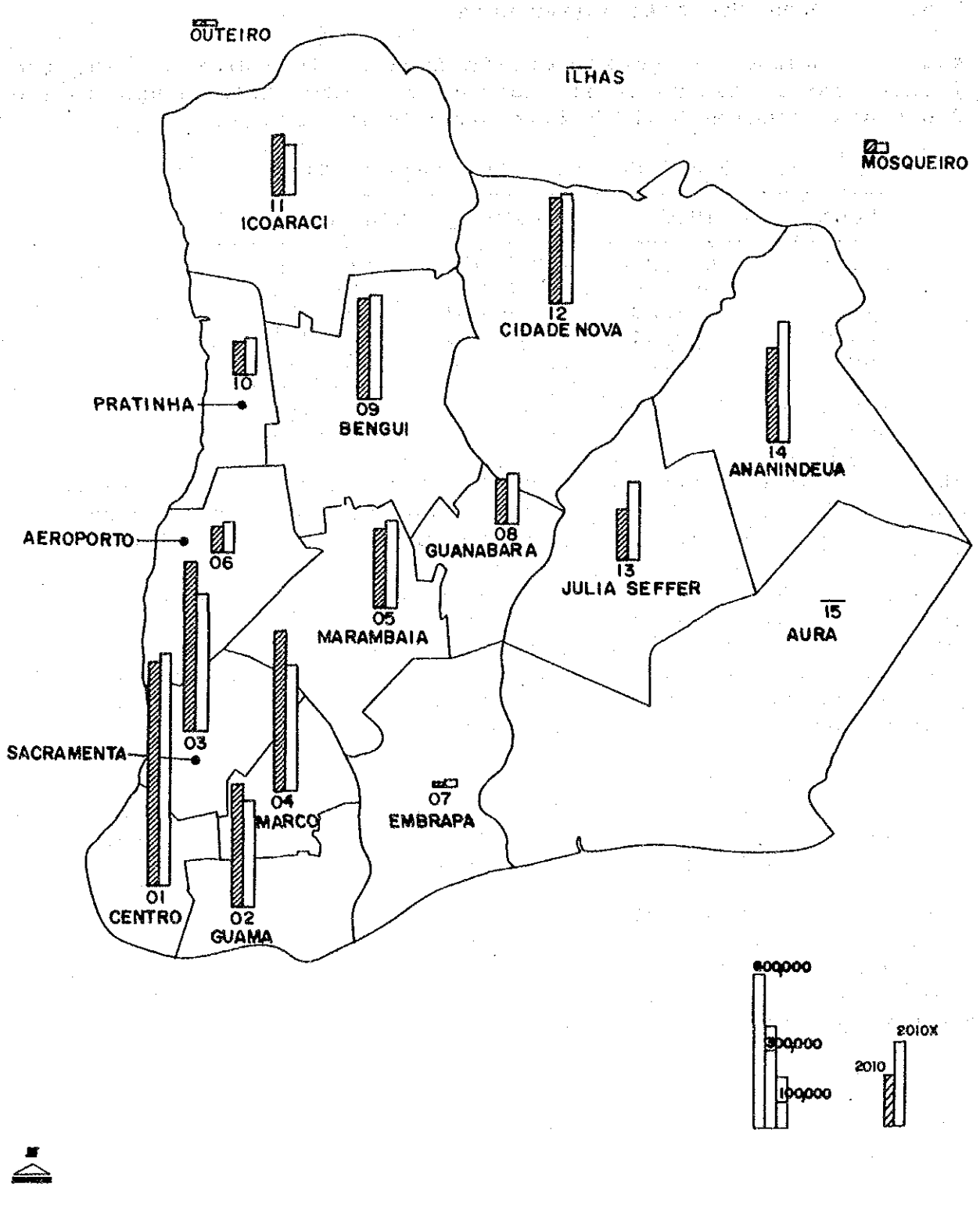


Figure 9.8-1 Change of Trip Generation by Land Use Alternatives

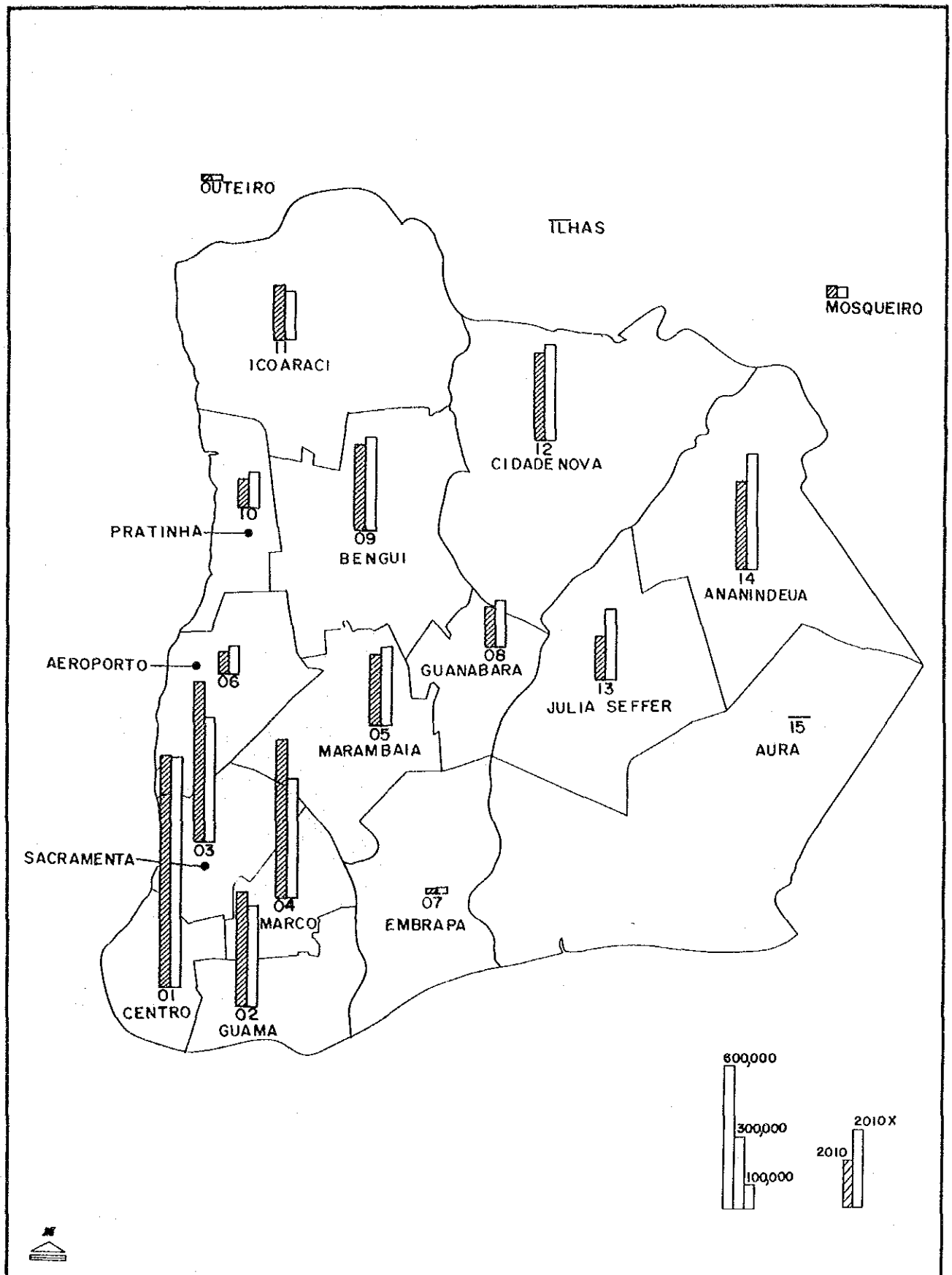
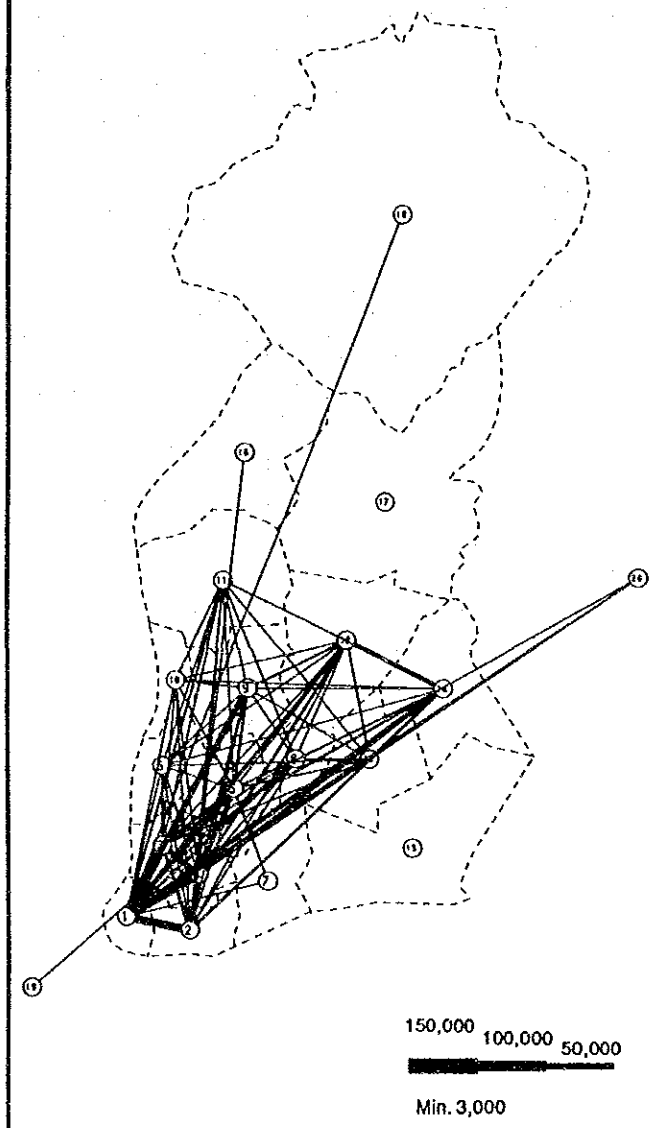
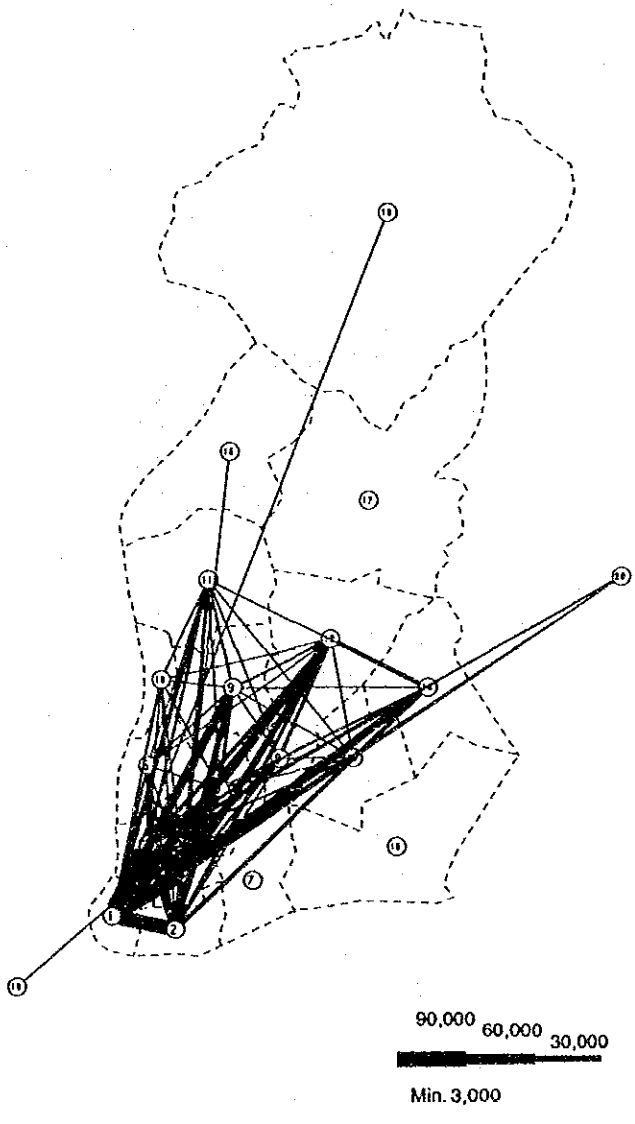


Figure 9.8-2 Change of Trip Attraction by Land Use Alternatives



Land Use Alternative



Land Use Proposed

Figure 9.8-3 Change of Trip Distribution

9.8.2 Vehicle Ownership Alternative Case

468. Assuming a case where vehicle ownership increases by 50 percent, future trip production in the Study Area increases as shown in Table 9.8-2.

Table 9.8-2 Future Modal Share of Trip

Mode	1990	2010	2010(base case)
walking	851,016	1,002,669	1,043,558
car	366,190	980,830	726,906
taxi	38,831	60,594	53,092
truck	86,446	178,869	136,287
bus	1,544,975	3,137,611	3,166,034
Total	2,887,458	5,360,573	5,125,877

469. Total number of trips increases by some 5 percent. Car trips increase only by 35 percent despite of 50 percent increase of car ownership. The reduction of bus trips is only 1 percent, therefore, it can be concluded that the influence on bus operation will be little in case of car ownership increase as the passenger number increases.

470. Trip generation and attraction by zone are shown in Figure 9.8-4 and 9.8-5, respectively. As car ownership is supposed to increase equally in all zones, the trip generation and attraction increase equally in all zones, accordingly.

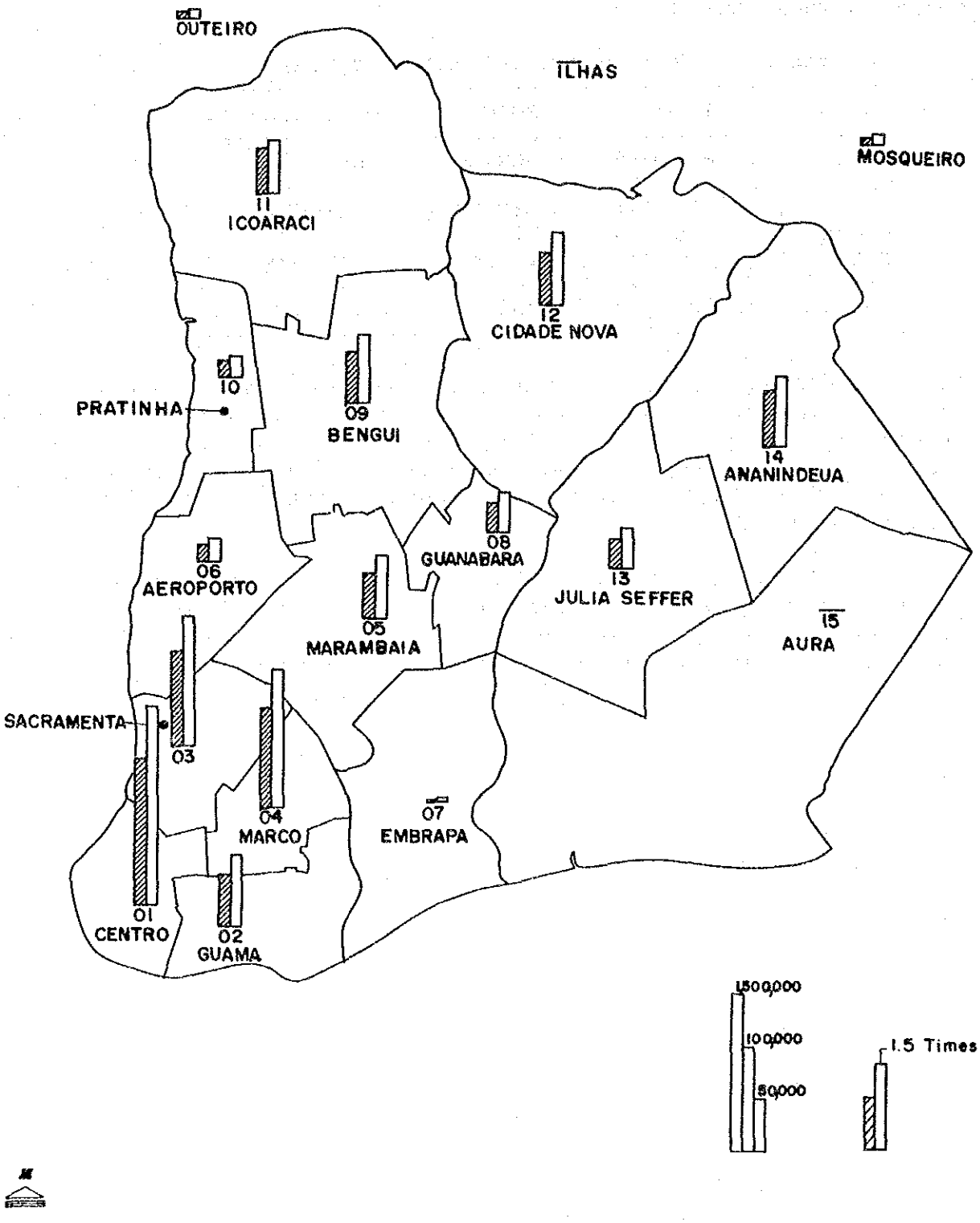


Figure 9.8-4 Change of Trip Generation by Car Ownership Alternative

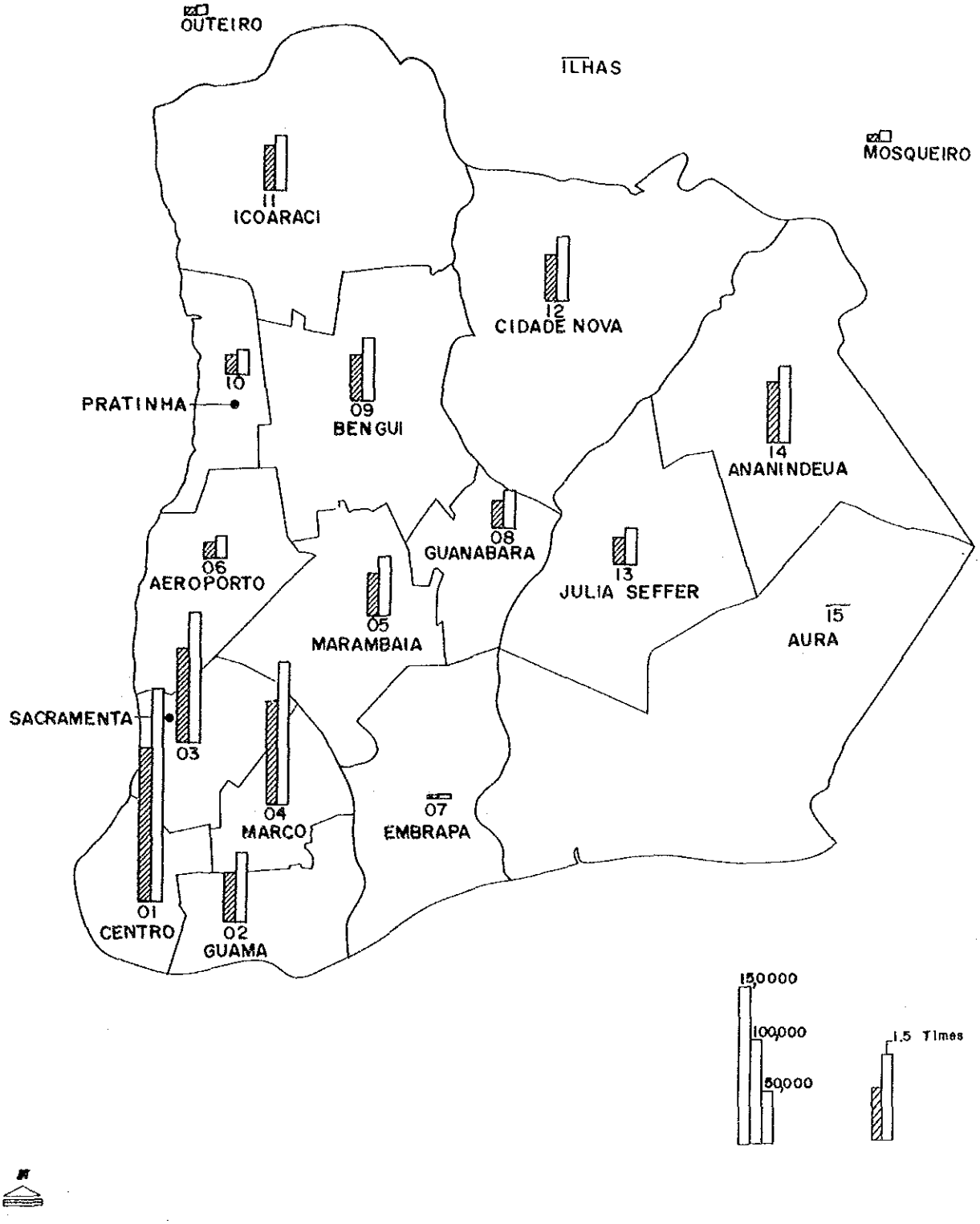


Figure 9.8-5 Change of Trip Attraction by Car Ownership Alternative

10. Basic Transport Policies

Local Bus Stop ▼

10.1 Introduction

471. In a motorized society, the excessive use of vehicles brings with it the adverse effects such as traffic congestion, traffic accidents, noise and air pollution, etc. The rapid growth of the private car ownership is a major contributor to this problem and the transport network improvement is usually late in meeting the growing demand of traffic. One of the principal reasons to establish the public mass transit system in the urban area is to lessen the transport demand pressure on the road network system.

472. In Belem, car ownership is still at a low level of about 70 vehicles per thousand persons and is forecasted to be only about 80 in the year of 2010, even as the vehicle number will nearly double. As explained in the previous chapters, the present traffic flow on existing road network has few of the problems usually faced by major arterial and distributor roads.

473. Although the future traffic flow based on the demand analyses on existing road network shows traffic congestion on several major roads, such road sections are mostly in the suburban area where the road network system needs improvement due to the expansion of residential area. (refer to Figure 10.1-1 and 10.1-2) In the central area, there are few traffic flow problems in as much as there is sufficient road network density in the area. (refer to Figure 10.1-3)

474. Therefore, it can be concluded there is no need to restrict private car ownership in Belem now and in future, but it is advisable to introduce the public mass transit system in near future in order to lessen the private car traffic on road network.

475. In the Study Area, the major improvement target of the transport network are as follows;

a. strengthening of the transport capacity between the central and suburban area, and
b. construction of the network in suburban area.

476. Present land use and population distribution show a concentration of socioeconomic activities in the central area within the 1st Patromonial League. Half the population lives in this area and some 65 percent of the employment is concentrated in the area.

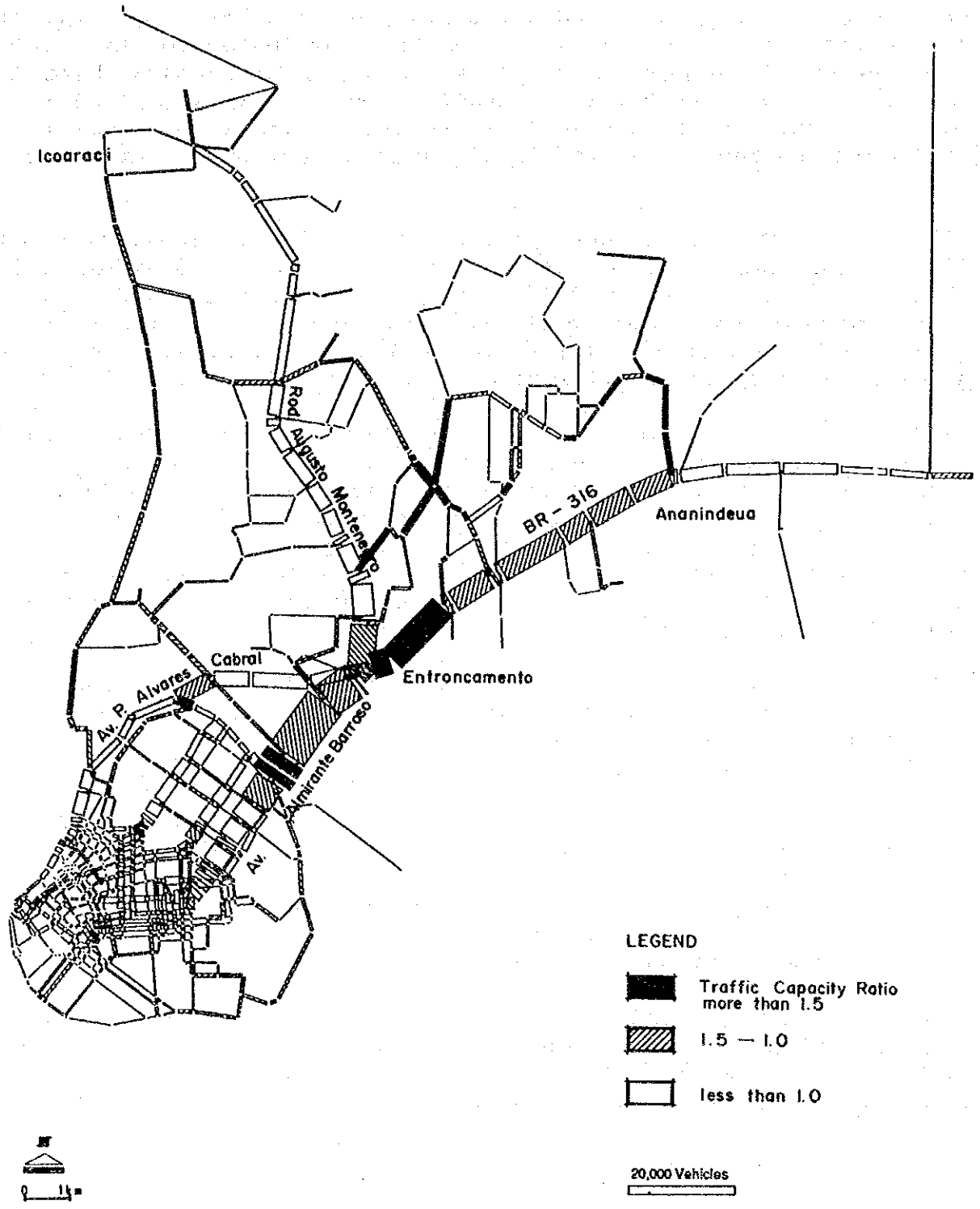


Figure 10.1-1 Traffic Flow in 2000

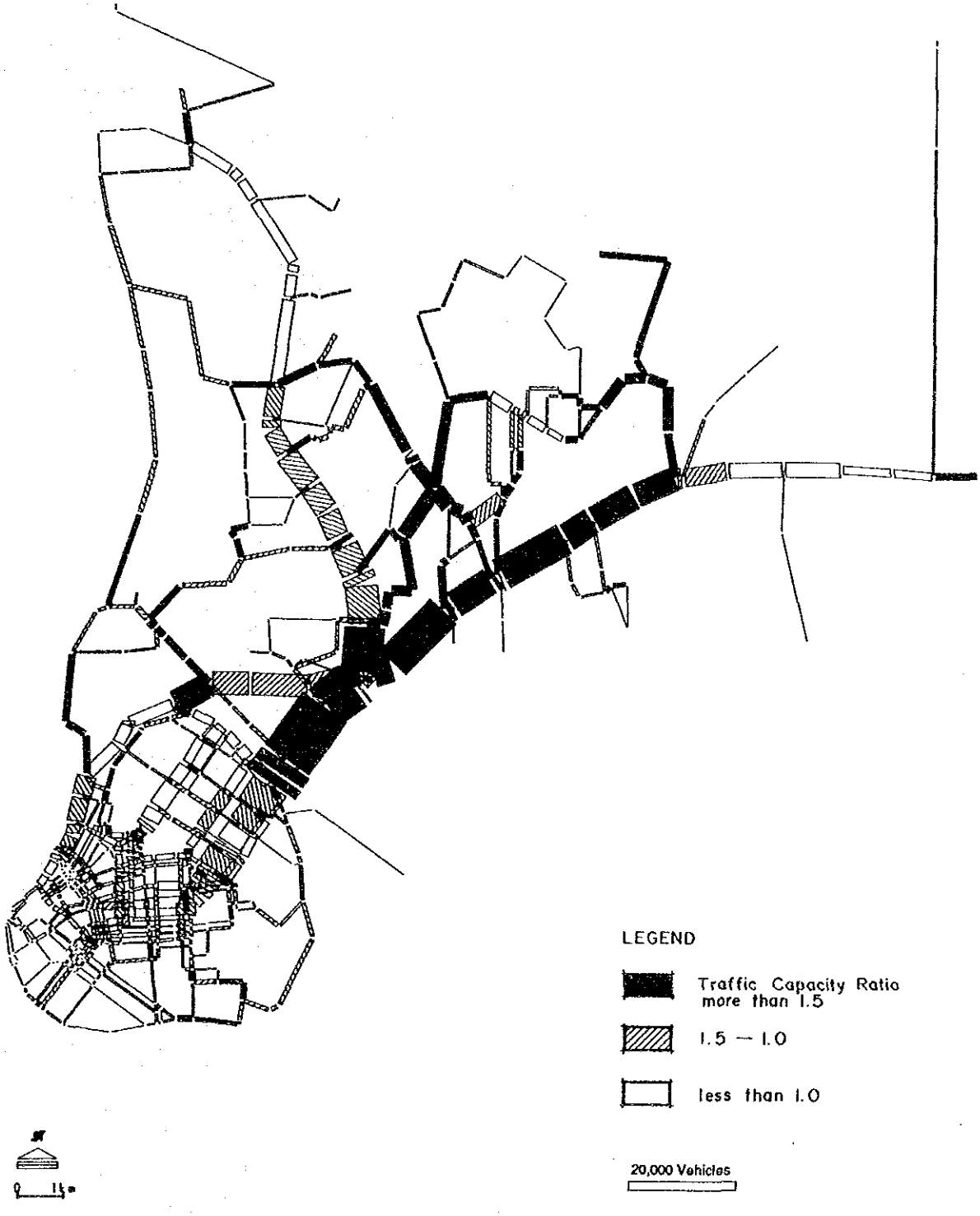


Figure 10.1-2 Traffic Flow in 2010

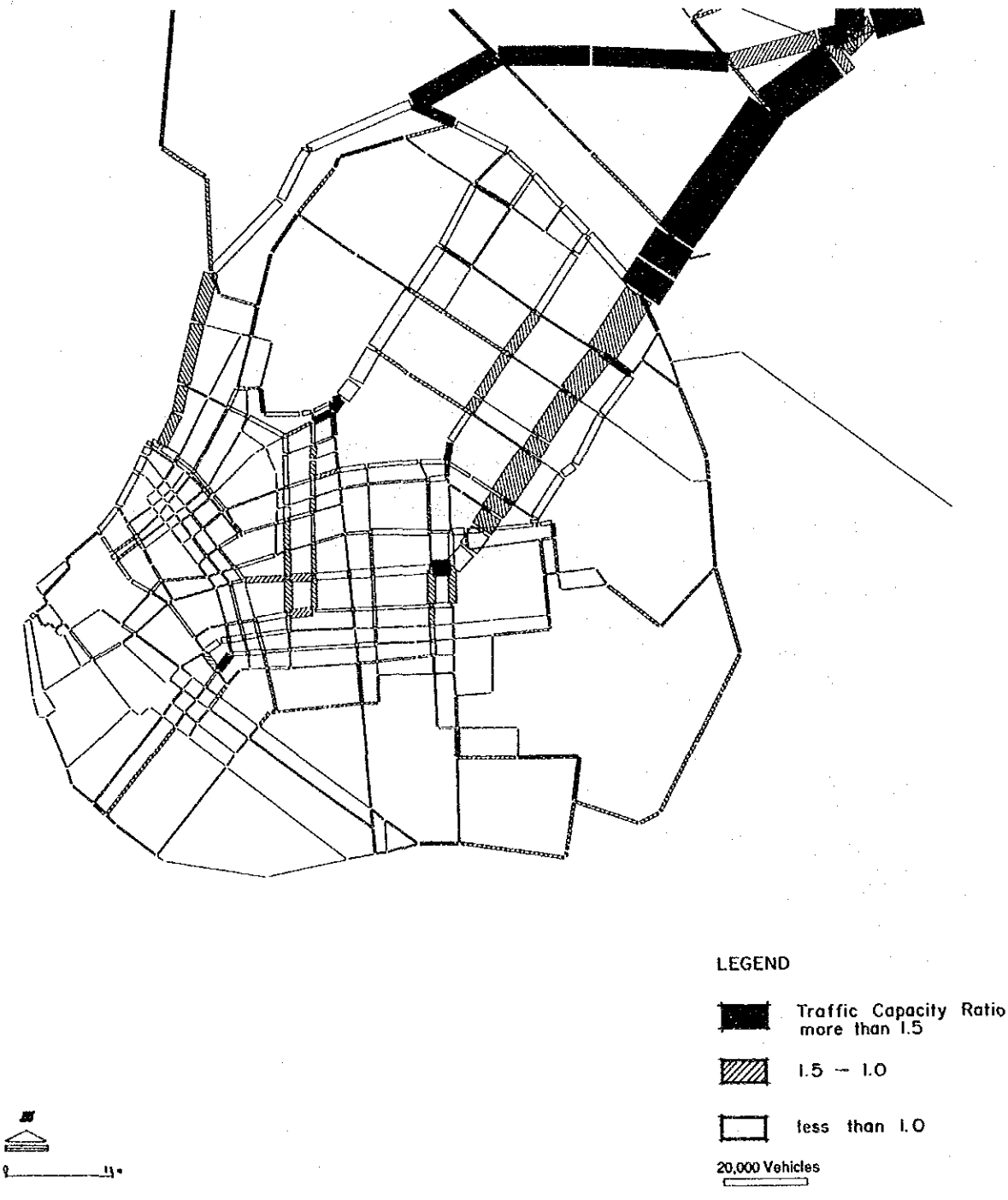


Figure 10.1-3 Traffic Flow in Central Area (2010)

477. Proposed future land use anticipates additional population distribution mostly outside the central area and the employment distribution of some 60 percent in the central area, a lesser distribution than at present. Under this socioeconomic conditions, the future traffic flow shows the same pattern as present one.

478. Table 10.1-1 shows the comparison of road traffic demand and capacity, while Table 10.1-2 shows the comparison of public transport demand and capacity between the central area and suburban area. Demand will exceed the capacity before the year of 2000, if no improvement will be made to the transport network between the two areas.

479. In the suburban area, the developments of the residential areas are expected to be continued in the area apart from the major existing arterial roads such as BR-316 or Rd. Augusto Montenegro. The distributor road network is now very poor in quality and also in quantity. Therefore, the present network system can not support the future traffic demand without any improvements.

Table 10.1-1 Comparison of Road Traffic Demand and Capacity(existing)

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 10.1-2 Comparison of Public Transport Demand and Capacity(existing)

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

480. In order to meet such future traffic demand, which will be double that at the present, alternatives of the transport network are examined from the view points of basic needs for transport planning described below.

481. Basic needs for transport planning are as follows:

a. To satisfy the transport demand of the Area,
b. To utilize the existing traffic facilities effectively,
c. To provide equal access to the transport facilities for the residents,
d. To provide adequate transport services for middle as well as low income peoples in lieu of present poor transport conditions,
e. To improve the transport network in line with the future land use,
f. To minimize the adverse effects to the environment, and
g. To use the resources economically.

10.2 Land Use and Urban Planning

482. The trend of the urban evolution at present in the Study Area is summarized as follows:

a. Segregation of residence area by income level (high income class in central area and medium and low income class in suburban area)
b. Concentration of such urban functions as the administrative, commercial and service activities into central area despite the small population growth, and
c. Expansion of the residential area in the suburban area.

483. As a result of this tendency, it is foreseen that the traffic flow between the central area and the suburban area will impact heavily on existing transport facilities in future. In order to lessen as much as possible these pressures on the transport network, the sub-centers, as urban activities core, are planned to be established in the areas of Icoaraci, Entroncamento and Ananindeua and the secondary and tertiary industries are encouraged.

10.3 Road Network Planning

484. As for the traffic corridor between the central area and the suburban area, existing road network has only the following three (3) routes (refer to Figure 10.3-1);

a. BR-316 - Av. Almirante Barroso
b. Rd. Augusto Montenegro
c. Av. Pedro Cabral

485. However, at the section across the Institutional zone, only two (2) routes of BR-316/Av. Almirante Barroso and Av. Pedro Cabral are available for traffic and most of the traffic flow concentrates into BR-316/Av. Almirante Barroso route. To meet the future demand between two areas above mentioned, the improvement of traffic capacity of the road network across the Institutional zone is a high priority in the road network planning. In the meantime, it is also important to improve and establish the distributor road network in suburban area so as to support the future socioeconomic activities in the Area. (refer to Figure 10.3-2)

(1) Improvement of Arterial Road Network

486. The following improvements are considered necessary;

1) Arterial roads between the central area and suburban area,

a. Extension of 1o de Dezembro
b. Central penetration highway between Cidade Nova and Ver-o-Peso
c. Extension of Av. Pedro Miranda and connection with b.
d. West side highway connecting Rd. Augusto Montenegro and Ver-o-Peso

2) Arterial road integrating suburban area

a. Arterial road construction between Icoaraci and Ananindeua (connected with PA-150)

(2) Improvement of the distributor road network in suburban area

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

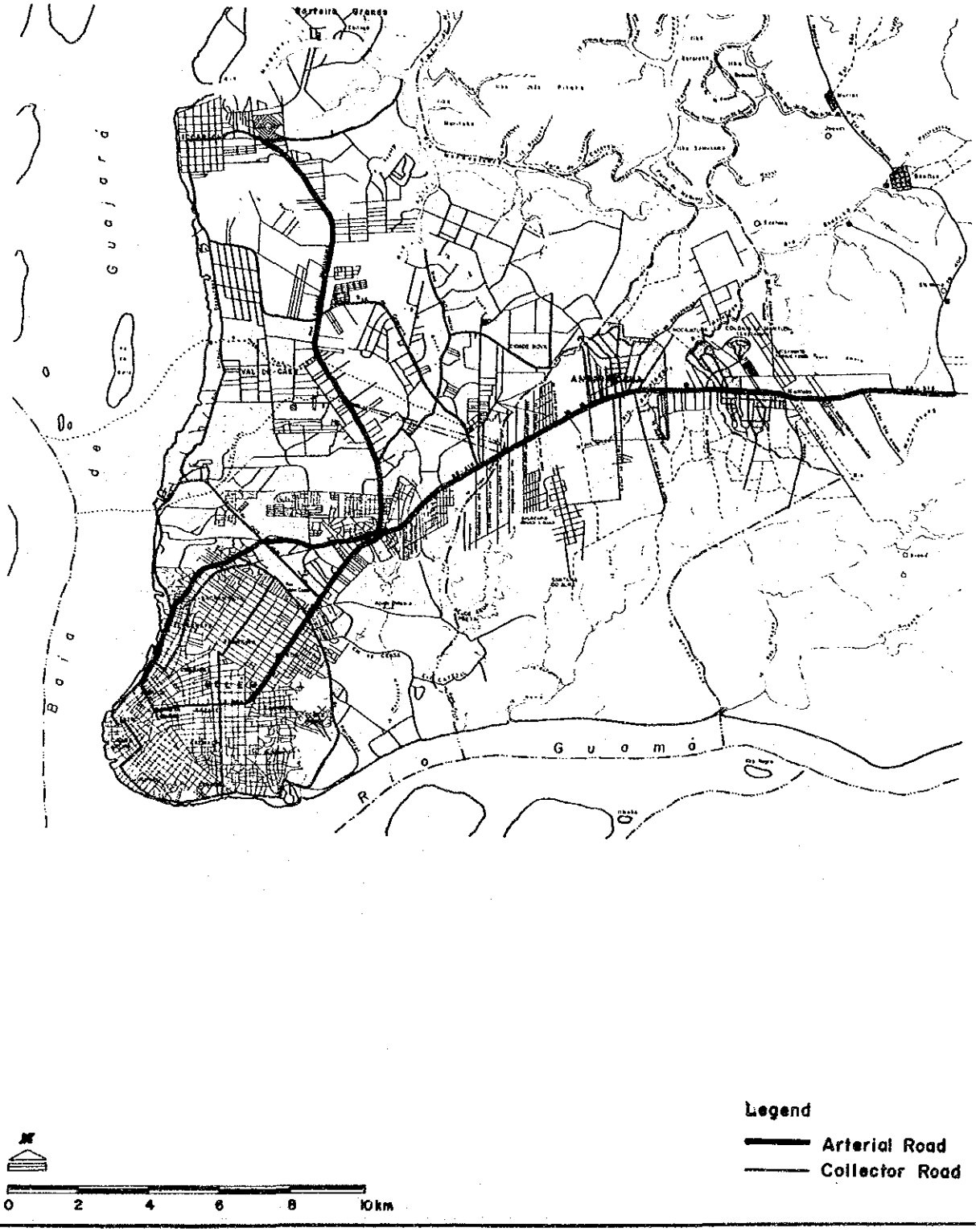


Figure 10.3-1 Existing Road Network (1990)

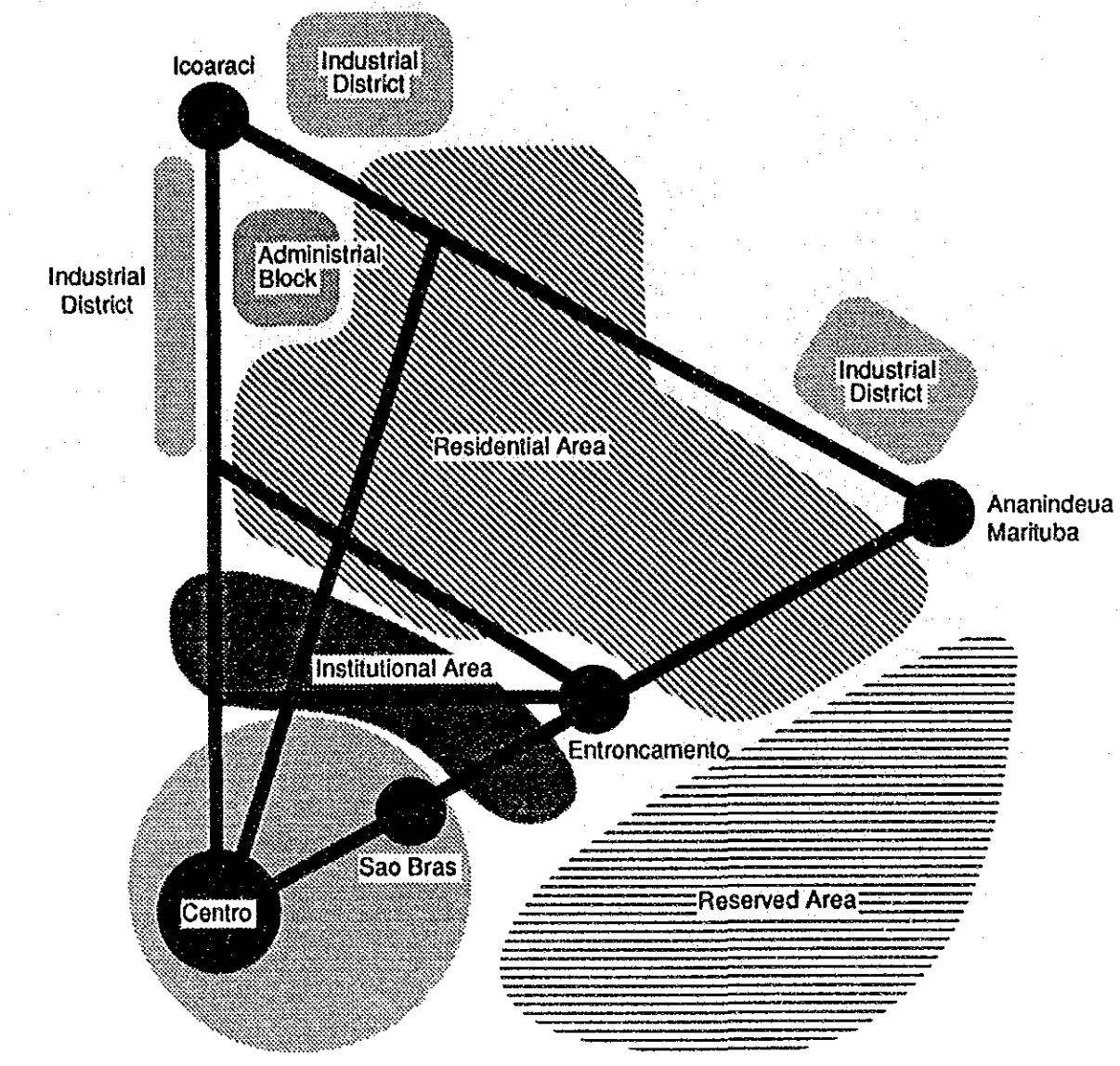


Figure 10.3-2 Future Arterial Road Network Diagram

10.4 Public Transport Network

488. Currently, the transportation by public transport reaches at the level of almost 80 percent of total transport demand excluding walking trips and will be the same in the future. The major directions of this public transport flow are those between the central area and suburban area. This tendency will continue to the future and the improvement of the capacity of the public transport between two areas is the subject of the future network.

489. From socioeconomic point of view, the improvement and strengthening of the public bus transport is more feasible than the introduction of mass transit system such as the heavy railway system. However, taking into consideration that the passenger volume between two areas will become more than 600 thousands after the year 2010, it will become necessary to introduce railway system on some traffic corridors after 2010 therefore, the possibility of railway system introduction for mass transit in BMR should also be examined.

490. Existing public bus system of the individual route operation in Belem operates every bus from terminal by round trip on specific route. Therefore, 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.

491. Following is the improvement plans of public bus operation system in the future:

a. Introduction of trunk bus operation system;
In accordance with the demand growth, introduce several trunk bus operation routes on major arterial and distributor roads.

b. Introduction of zone bus operation system;
Introduce the zone bus operation routes on road network in connection with trunk bus operation.

c. Investigation of public railway operation system;
Examine the introduction of public railway operation system on the corridor on which the demand is forecasted to concentrate.

d. Introduction of para-transit system;
So as to lessen the traffic flow of the private transport by introduction of multi transport systems, investigate the possibility of the introduction of para-transit system such as small size and more comfortable public transportation with higher tariff.

10.5 Traffic Control and Management

492. To ensure smooth traffic flow at present and in the future, it is necessary to review the signal control system, one-way traffic system, parking regulation, etc. By introducing the trunk bus operation system on major roads, the road space for the private traffic flow will reduce and it will shift to other roads and streets in the central urban area. Additionally, the increase of the traffic flow into the central area will be accompanied by the parking demand increase which will make it necessary to improve the parking control and managing regulation.

493. The following is the basic plan of the improvement of the traffic control and management;

a. Classification of road hierarchy
Make the standard for planning the traffic control and management by identifying the road classification such as artery, and secondary roads.

b. Improvement of traffic signal system
By introducing the variable phase signal controller and central control computer system, improve the traffic signal system on arterial roads.

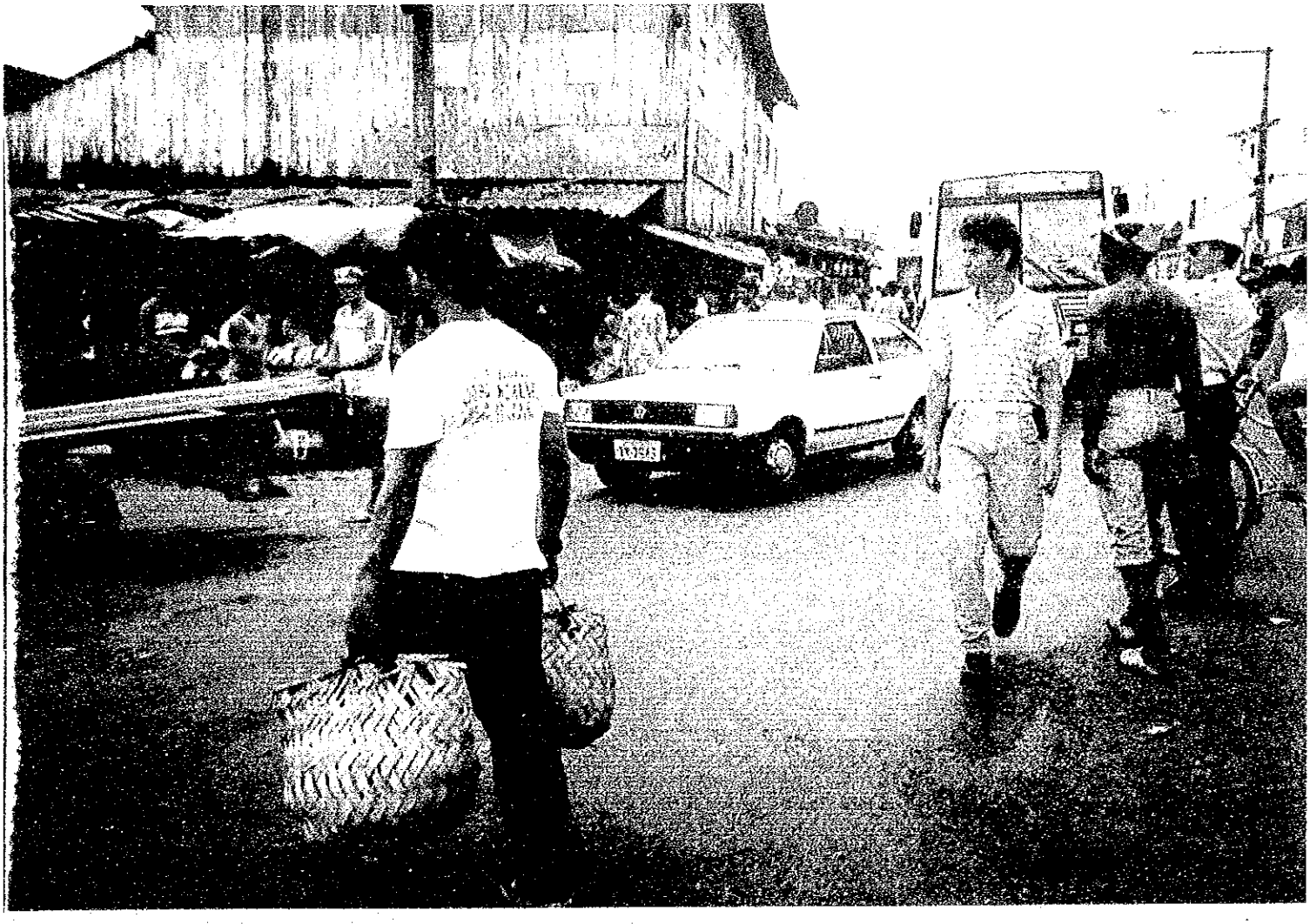
c. Improvement of intersection
In order to make the traffic flow smoothly in some sections where traffic flow concentrates, improve the geometrical feature and signal system.

d. Review the one-way road formation
In order to meet the traffic flow movement by the introduction of trunk bus system and traffic volume growth, review and revise the one-way road formation.

e. Investigation of parking regulation
For the future traffic volume growth and parking demand increase in the central area, investigate the parking restriction regulation on arterial roads and create parking spaces on secondary roads.

11. Road Network Planning

Roadside Condition at Av. B. Sayao ▼



11.1 Planning Policy

494. The road network and the future demand in BMR can be summarized as follows;

(1) The road network in the area within Av. Perimetral forms the grid pattern with intervals of 200m - 300m, and roadside area are built-up, however the paved road percentage is still low except in some areas. The construction of new roads or widening of roads in this area require the demolition of buildings and houses and are expected to face to serious social problems. Figures 11.1-1 through 11.1-6 show the desire lines from the main future development area of Icui Guajara, Curucamba, Julia Seffer, Poto Macho, Sao Palmeira and Marituba where more than 30,000 additional inhabitants are expected to reside by the year 2010. Only Icui Guajara and Curucamba show lateral traffic movement to the Industrial Area in Ananindeua, however the main flow remains in the radial direction to the Central area.

(2) The road network outside of Av. Perimetral consists of few paved trunk roads such as BR-316, Augusto Montenegro and Arthur Bernardes. The demand generated from the housing estates scattered in the sub-urban area concentrates to these trunk roads even at present.

(3) The future traffic demand within the built-up area (central area) will not grow so much, while the demand between the built-up area and the suburban area or within the suburban area will grow sharply (Fig. 11.1-7).

(4) The roads connecting the central area and the suburban area through the institutional belt are Arthur Bernardes (undivided two lanes) and Alm. Barroso (eight lanes). The 3rd road of P.A.Cabral (four lanes) will be opened throughout the extension. The demand/capacity balance is shown in Table 11.1-1. The volume/capacity ratio (V/C) in terms of AADT is 0.86 at present and will reach to 2.5 in the year 2010 under the present condition (Do-Nothing Case), which means that eight more lanes in addition to the present 14 lanes will be needed to maintain V/C below 1.0 in the year 2010. If four lanes out of the present eight lanes on Av. Alm. Barroso is occupied as exclusive bus lane for the introduction of the trunk-feeder bus system in the future, ten more lanes will be required by the year 2010.

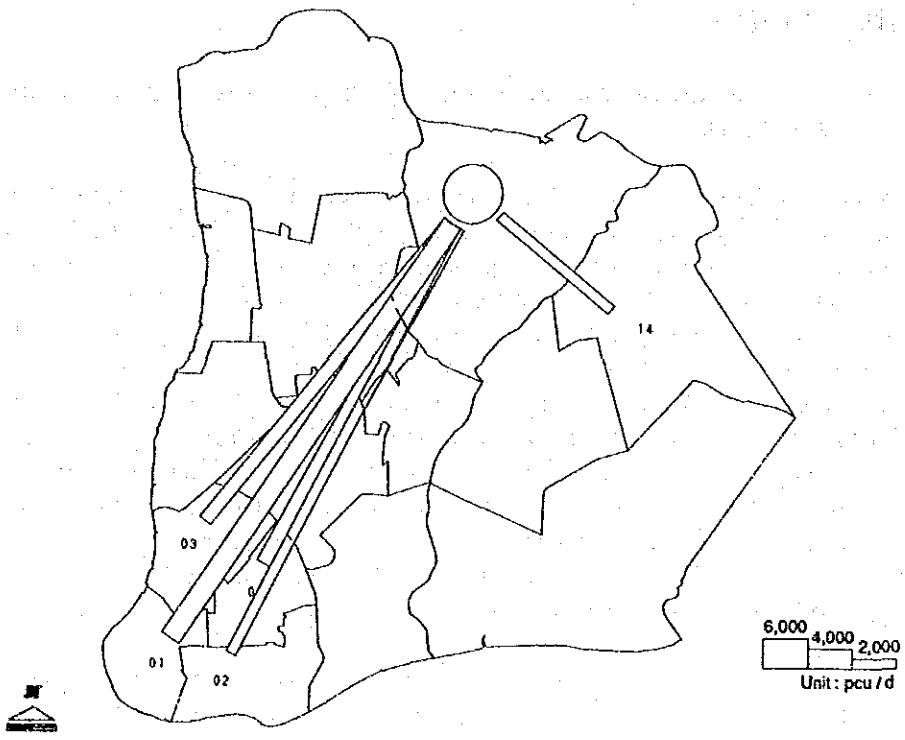


Figure 11.1-1 Desire Line From Icui Guajara (Zone 62)

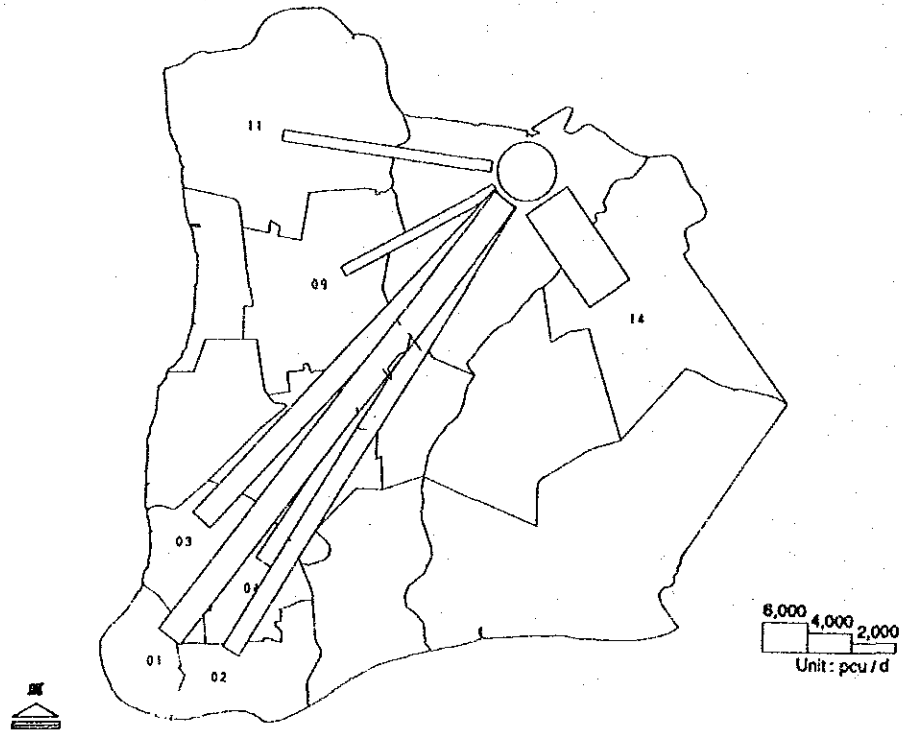


Figure 11.1-2 Desire Line from Curucamba (Zone 63)

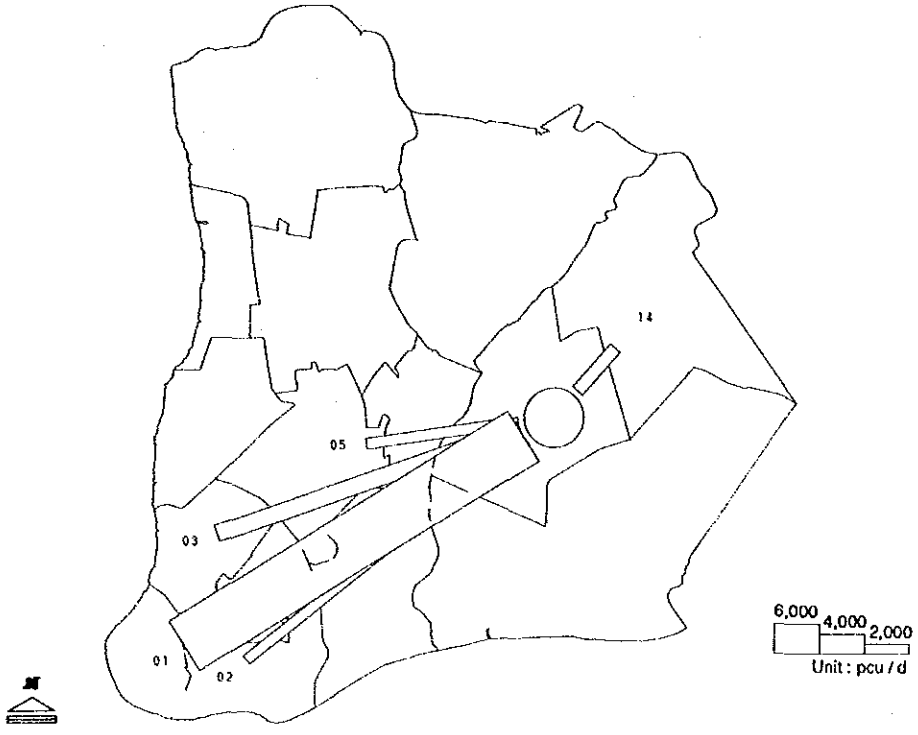


Figure 11.1-3 Desire Line from Julia Seffer (Zone 72)

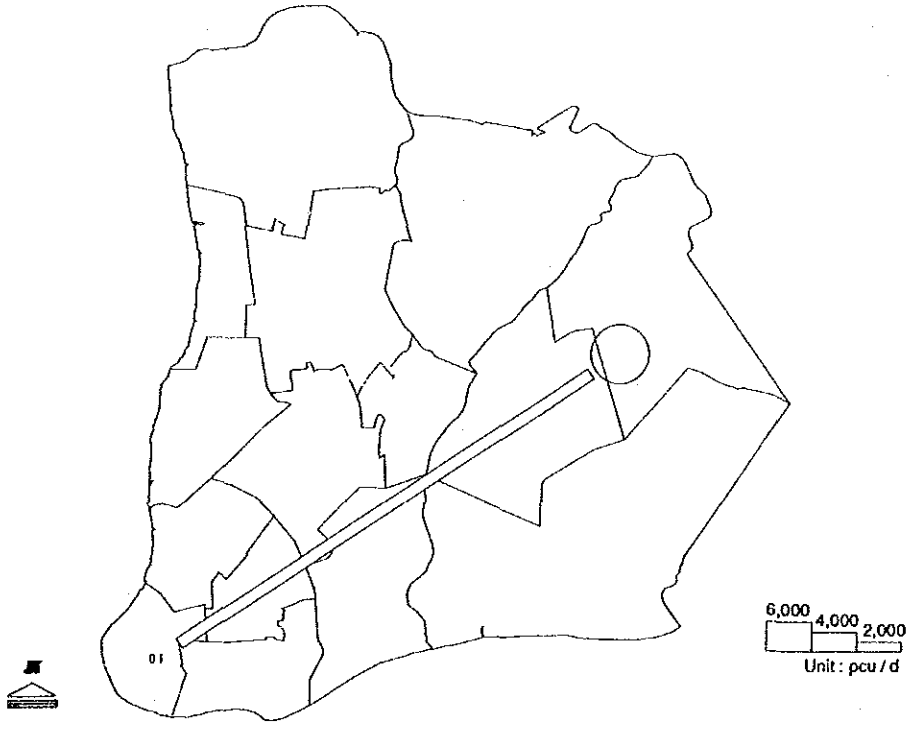


Figure 11.1-4 Desire Lone from Pato Macho (Zone 73)

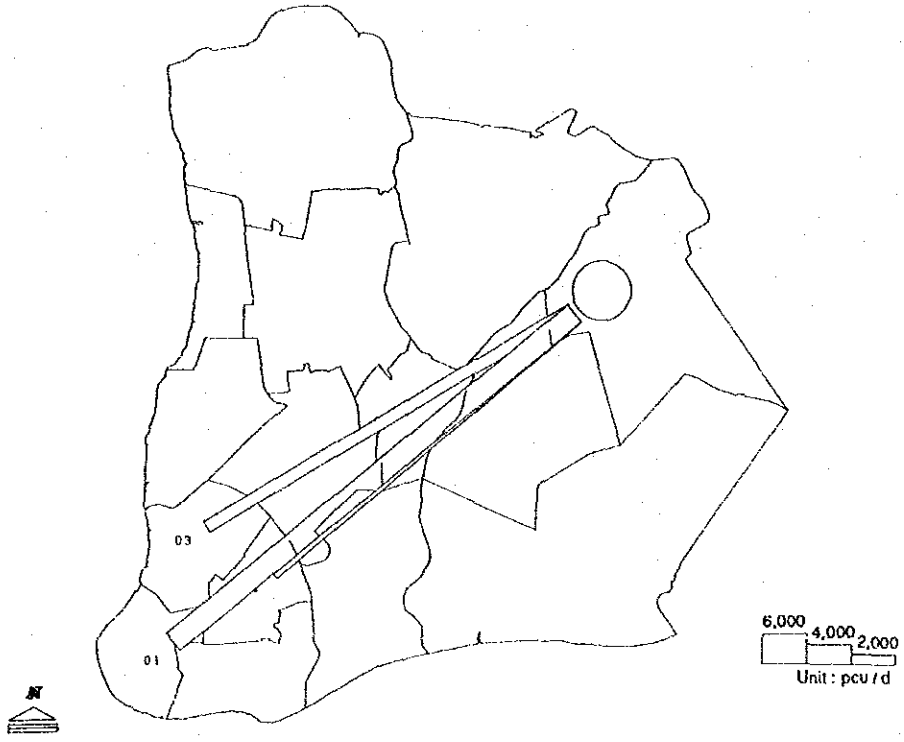


Figure 11.1-5 Desire Line from Sao Palmeira (Zone 76)

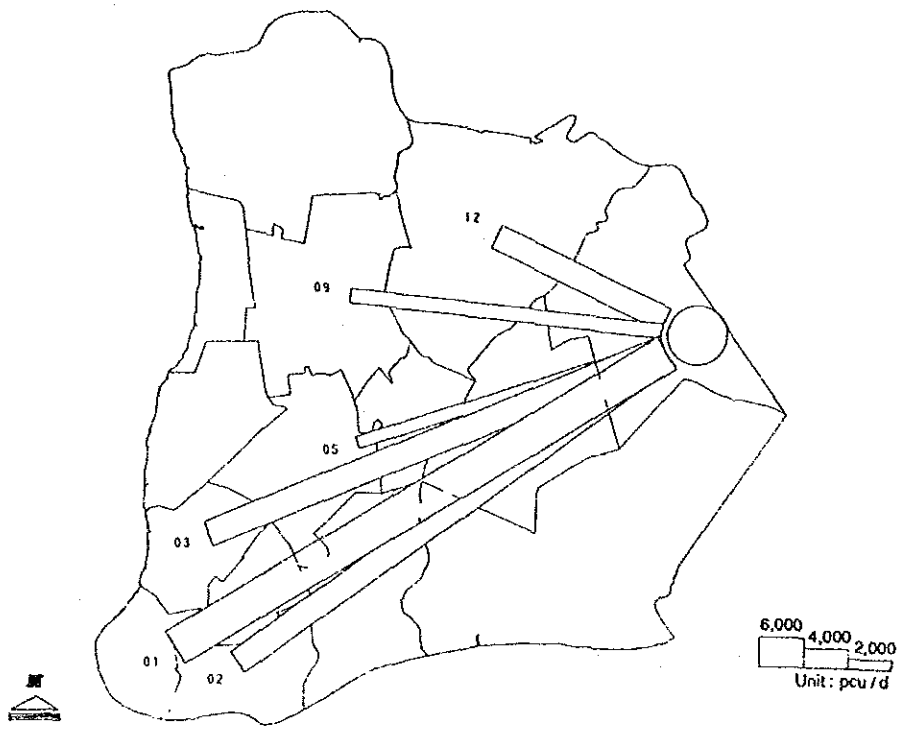


Figure 11.1-6 Desire Line from Matiruba (Zone 80)

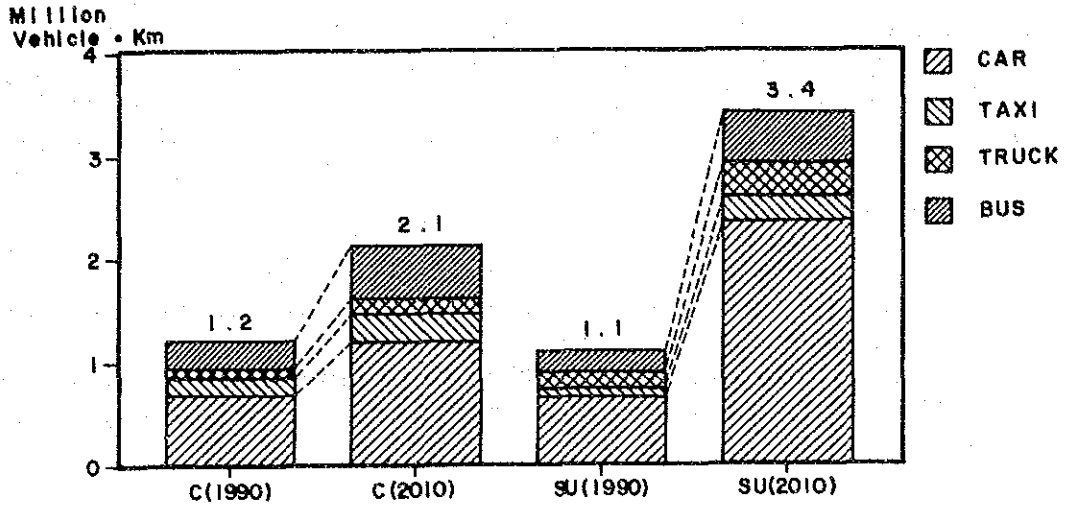


Figure 11.1-7 Growth of Vehicle-Km by Area

Table 11.1-1 Perimatral Section Demand/Capacity Balance
(Unit:PCU)

ROADS	1990		2010					
			DO NOTHING		W/O BUS LANE		W/ BUS LANE	
	LN NO	CAPACITY (PCU)	LN NO	CAPACITY (PCU)	LN NO	CAPACITY (PCU)	LN NO	CAPACITY (PCU)
1 Alm.Barroso	8	96,000	8	96,000	8	96,000	4	48,000
2 Pedro A.Cabral	4	48,000	4	48,000	4	48,000	4	48,000
3 Arthur Bernardes	2	12,000	2	12,000	2	12,000	2	12,000
4 1o de Dezembro					4	48,000	4	48,000
5 Rodvia do Belem					4	48,000	4	48,000
6 Pedro Miranda					4	48,000	4	48,000
TOTAL CAPACITY		156,000		156,000		300,000		252,000
DEMAND		117,000		261,000		261,000		261,000
V/C		0.75		1.67		0.87		1.04

495. Taking these circumstances into consideration, the future road network planning policy is established as;

(1) Figure 11.1-8 and 11.1-9 show the results of traffic assignment on "Do nothing" road network in the years 1990 and 2000 respectively. The average congestion rate (V/C) in the whole network is calculated at 0.39 in the year 1990, and will increase by 0.65 and 0.88 or 1.7 and 2.3 times the present in the years 2000 and 2010 respectively. One of the main targets of the masterplan network is to maintain at least the average congestion rate at the present level and to maintain the congestion rate by section below 1.0.

(2) In the outside of Av. Perimetral, especially in the area where the future development is expected, the trunk road network should be planned to form a grid with the interval of at least 2 - 3Km. The local road network within a development area should follow the trunk road network, and they should be planned by individual developers.

(3) PA-150 which is the state highway will be a trunk road in the future development area to connect the present poor access area with the existing two trunk roads of BR-316 and Av. Augusto Montenegro.

(4) Cidade Nova housing estate, which has one access to BR-316 through Rodvia Trans-Coqueiro at present, should have one or more access to the trunk roads.

(5) The extension of Av. 1o de Dezembro, which has been planned in BMR should be followed to increase the traffic capacity in the radial direction.

(6) On the Av. Arthur Bernardes, the section to cross the air port will be closed when Belem International Airport will be expanded (Fig. 11.1-10). Therefore, a by-pass to detour the airport area using the existing Estrada S. Clemente up to Av. Augusto Montenegro through Bengui residential area will be needed.

(7) One or more radial roads connected directly with the area within Av. Perimetral should be planned to cope with the future demand. To cross the Marambaia residential area, a road along Sao Joaquin River and the existing high tension line, and the extension of Av. Pedro Miranda will be the candidates.

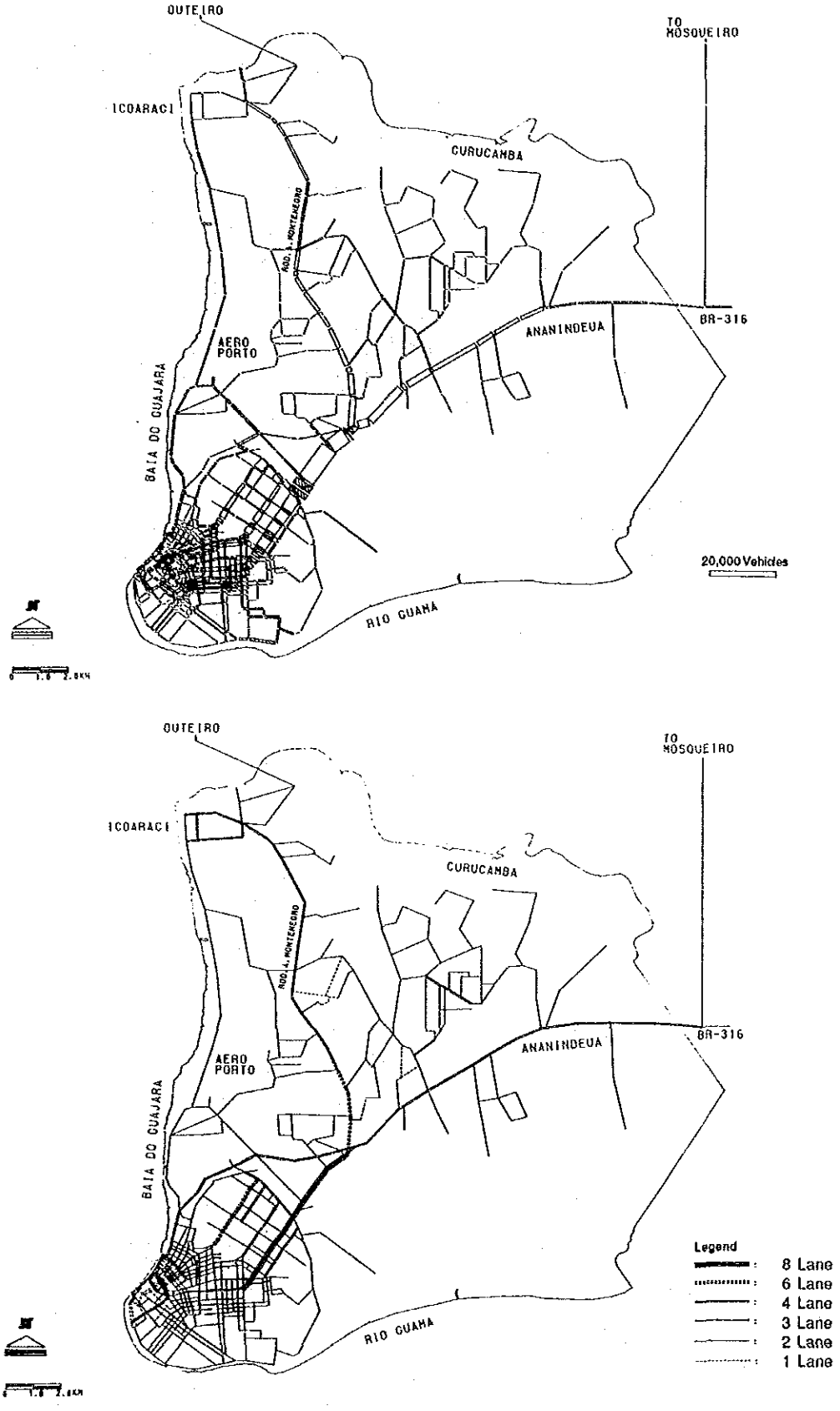


Figure 11.1-8 Result of Traffic Assignment in Year of 1990 and Road Network

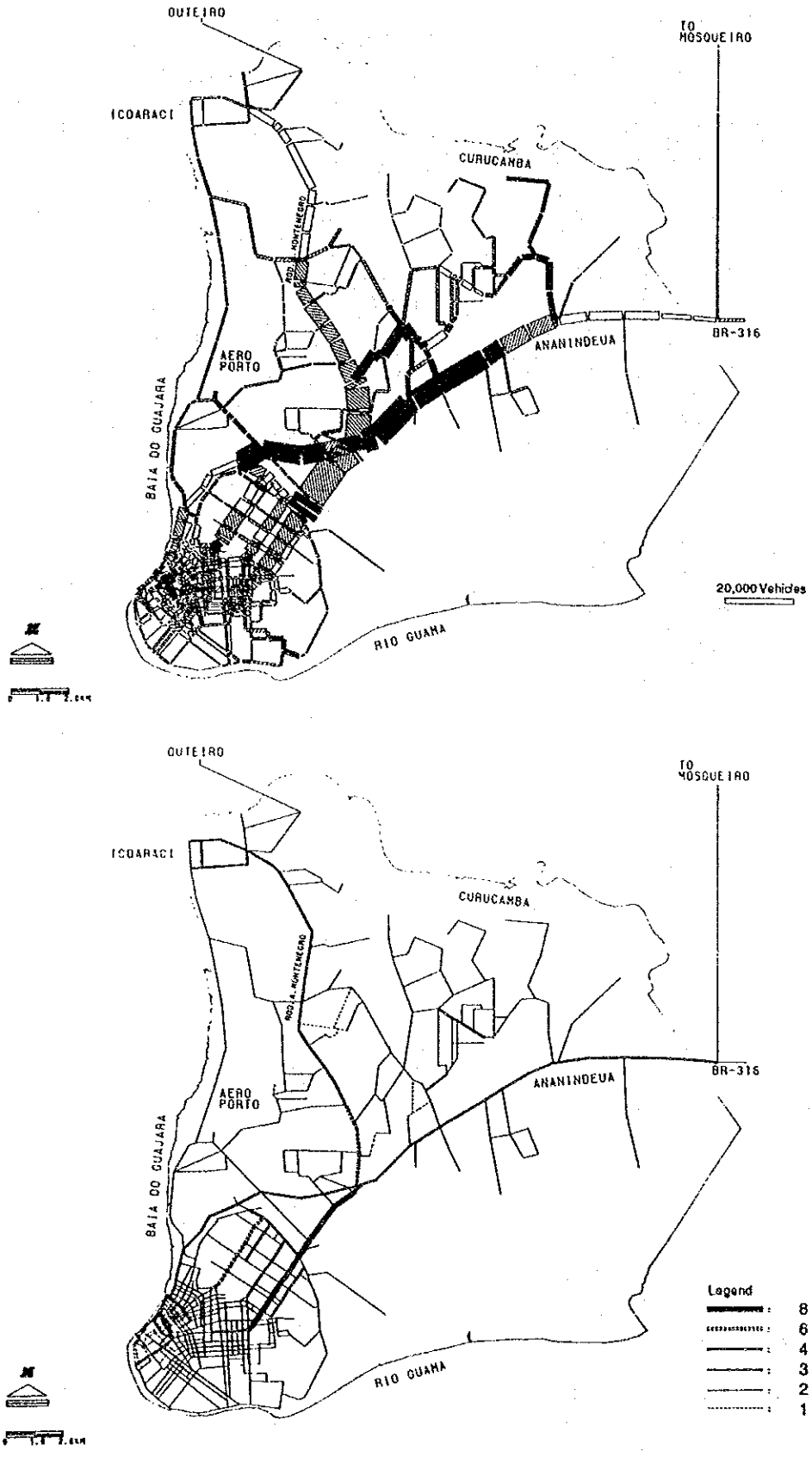


Figure 11.1-9 Result of Traffic Assignment in Year of 2010 and Road Network under Do-Nothing Case

(8) In the area within Av. Perimetral, the road network should be planned from the view points of;

a. A. Living Environment quality
b. B. Construction of missing link

Av. Bernardo Sayao, which passes along Guama River and the canal, will form a perimetral road of Belem built up area together with Av. Perimetral, when the road itself and the canal will be improved. This will provide a better environment for Guama lower area. The Una River basin has the same possibility.

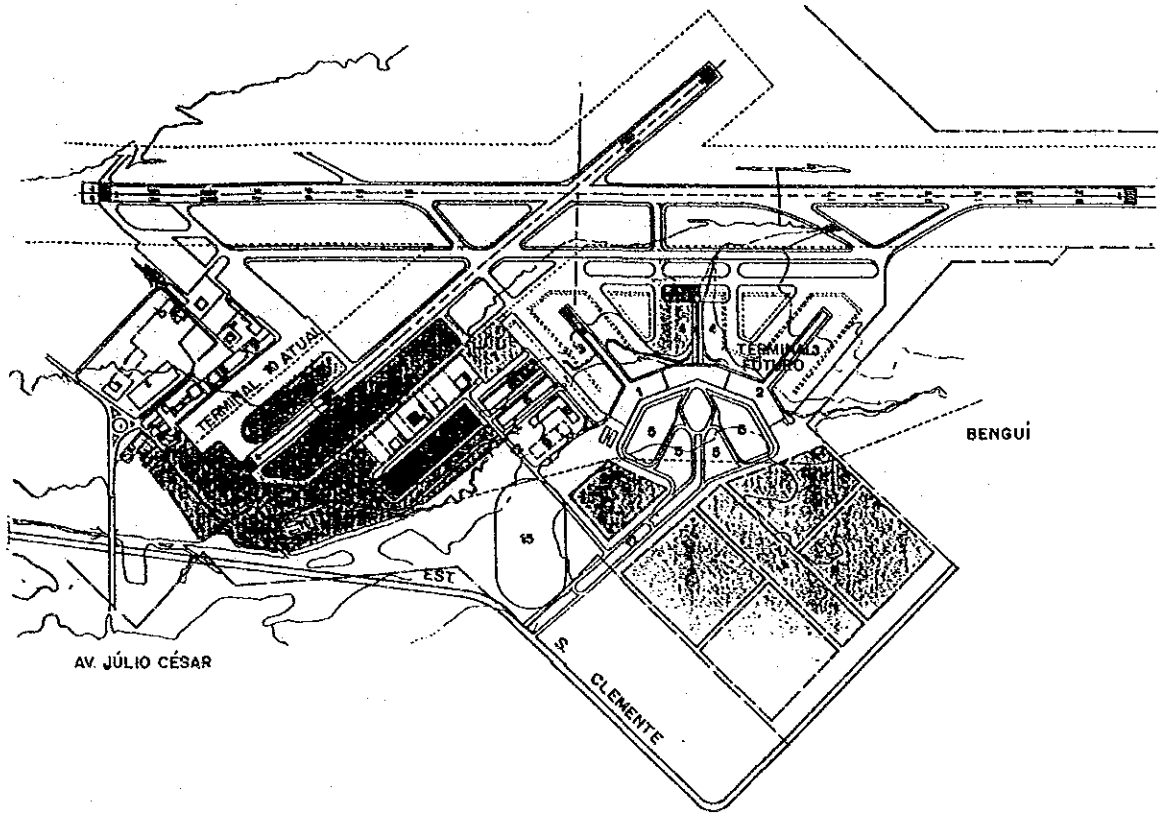


Figure 11.1-10 Belem International Airport Expansion Plan

11.2 Road Projects

496. The following 21 projects are selected from the above mentioned planning policy. Figure 11.2-1 shows the project location.

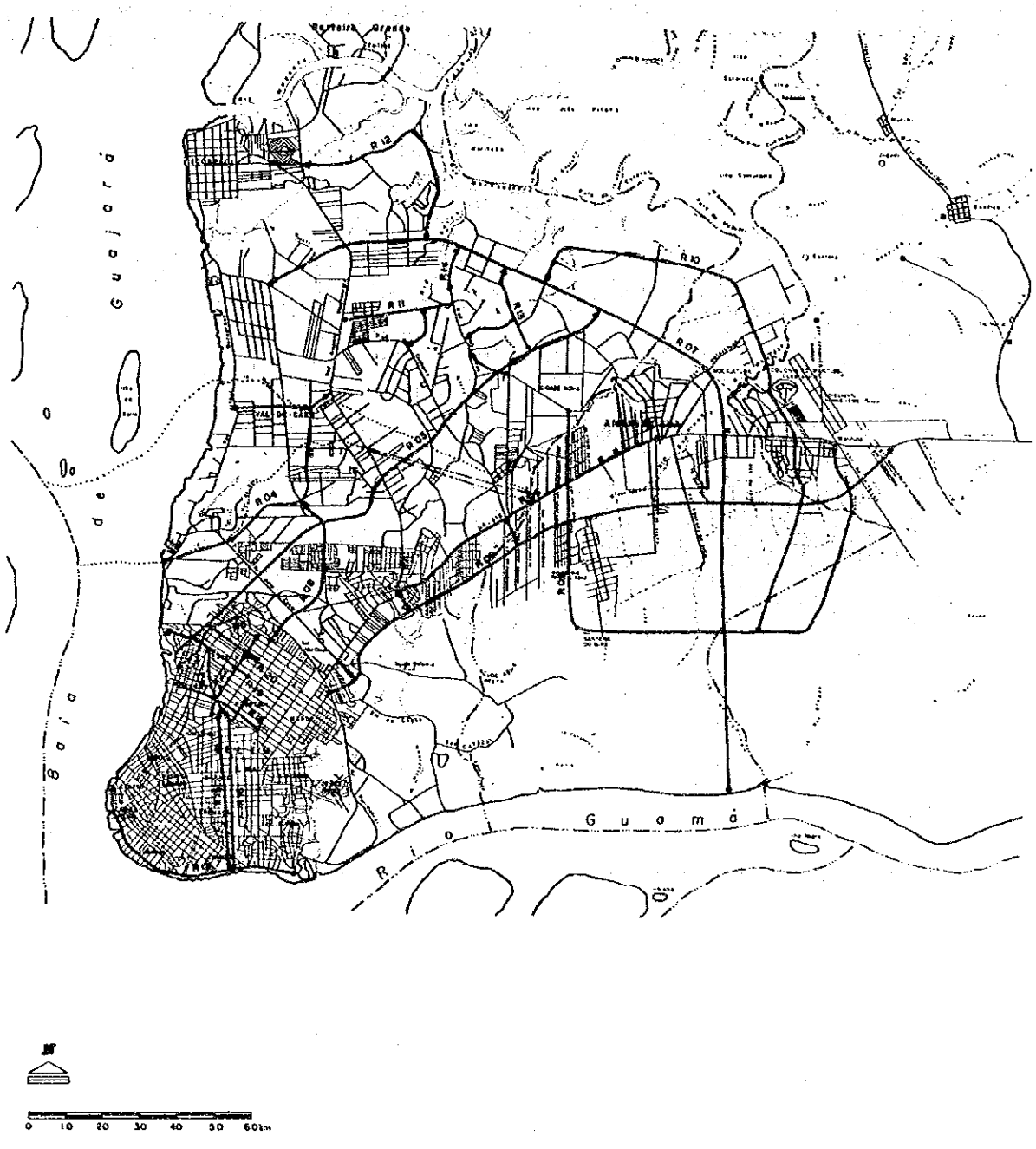


Figure 11.2-1 Road Project Map

(1) Av. Pedro A. Cabral (R01)

497. This road was constructed (with financing by IBRD) as six lanes road from Entroncamento up to the intersection with Av. Julio Cesar and four lanes road from this intersection to the intersection with Arthur Bernardes. The last 2.5Km section from Trv. A. Costa has been left unpaved until Oct. 1990 and the project aims to complete this section.

(2) Av. 1o de Dezembro Extension (R02)

498. Av. 1o de Dezembro at present starts at the corner with Av. Ceara in Sao Braz area and ends at the intersection with Av. Perimetral with 14m wide carriageways - six lanes and 4.7m wide median. The project aims to extend this road parallel with Av. Almirante Barroso and BR-316 up to the border of the Study Area, increasing the traffic capacity in this direction. This extension section has been planned in BMR and defined as trunk road. In the housing estate of Julia Seffer, ROW(Right of Way) has been secured (Figure 11.2-2).

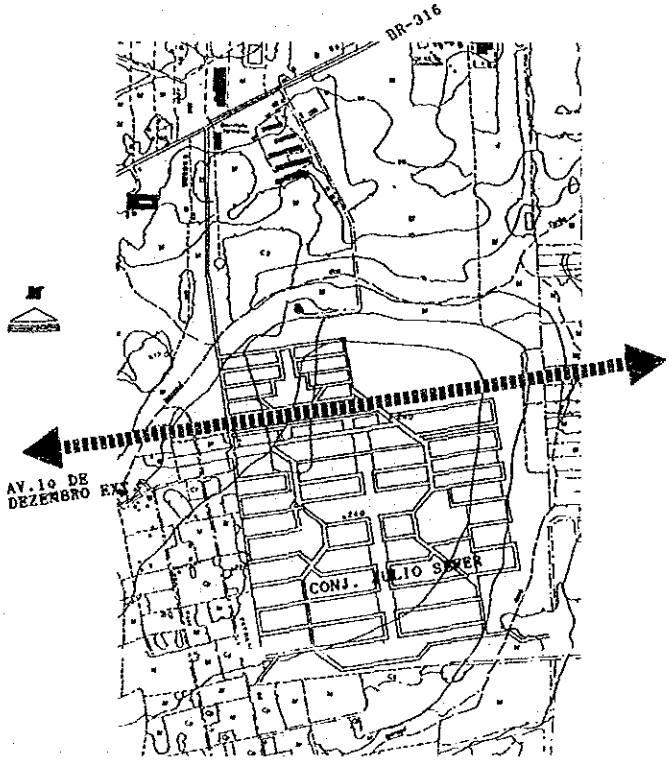


Figure 11.2-2 Project of Av. 1o de Dezembro Extension

499. The project requires some accesses between existing Av. Almirante Barroso / BR-316 and Av. 1o de Dezembro.

(3) Rodvia Belem (R03)

500. This road is planned with the aim to lighten the over concentration of traffic demand from the expansion area of Curucamba or Icui-Guajara where the housing estates with the population of about 50,000 (same size as Cidade Nova) is anticipated in future, to Entroncamento where four trunk roads of BR-316, Av. Almirante Barroso, Av. Augusto Montenegro and Av. Pedro A. Cabral coincide.

501. The road starts from the intersection with Av. Arthur Bernardes and runs along Igarape Sao Joaquin up to the intersection with Av. Augusto Montenegro. It will continue beyond this point up to the corner of Cidade Nova, along the electric transmission line to cross the area between Av. Augusto Montenegro and Rodvia Coqueiro, where many illegal housings (Invasao) are scattered. The entire length to PA-150 will be 16.5Km.

502. The project requires the improvement of Igarape Sao Joaquin and the relocation of transmission line.

(4) Val-de-Cans Bypass (R04)

503. The existing two lanes Av. Arthur Bernardes passes through the airport area and is closed at 10:00 p.m. until the following morning for security purposes causing inconvenience for the road users at present. The project provides the new route bypassing the airport to the east, using Estrada S. Clemente and crossing Bengui residential area, and will be connected to Av. Augusto Montenegro. The present 6.3Km section within the airport area will be closed to the public. The idea has been planned in BMR road network, however ROW in Bengui residential area has not been secured and some demolition of houses is expected.

(5) BR-316 (R06)

504. The road has about 60m ROW and 13m wide median, and is operated as two-way four(4) lanes road at present. The project aims to operate the road as eight(8) lanes road from Entroncamento up to the center of Ananindeua for a length of 8.4Km. The central two lanes on each side will be reserved for the public bus transport as the exclusive bus lane, when the zone bus system will be introduced.

(6) PA-150 (R07)

505. The road has been planned as the Para state highway No.150 from BMR to Carajas through Barcarena. The project forms a part of this scheme and the route was planned from the river side of Guama Rv. to Av. Arthur Bernardes surrounding the expansion area for the length of 25.6Km.

506. The road is defined as a Frame Road in BMR road network and in the housing estate of Geraldo Palmeira, ROW has been secured (refer to Figure 11.2-3). The road is expected to form an axis in the future housing development area of Curucamba and Icui-Guajara together with Rodvia Belem.

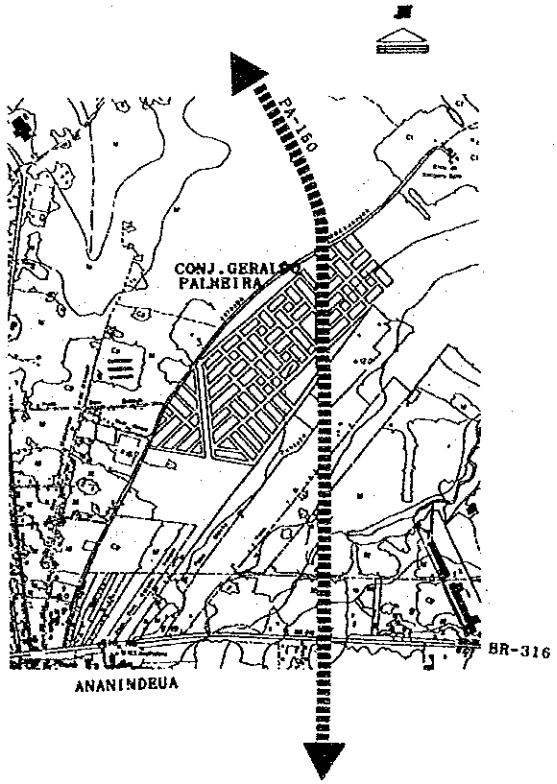


Figure 11.2-3 Project of PA-150

(7) Av. Pedro Miranda Extension (R08)

507. Av. Pedro Miranda, which has two lanes marginal roads on both sides and two lane center carriageway, totally six lanes, starts from the corner with Av. Alcindo Cacella and ends at the intersection with Av. Dr. Freitus at present. The project is expected to extend the road, crossing the existing airport (for light planes) via Marambaia residential area up to Val-de Cans Bypass for the length of 4.9Km.

508. The airport which has 30m x 1500m runway (refer to Figure 11.2-4) prevents the access from the expansion area to the central area, and the relocation of the airport has been studied a few times, however for various reasons in the relocation area, or relocation fund, etc. the plans were rejected. The area should be reserved as a greenery adjacent to the central built-up area, however as the traffic demand in 2010 crossing the area will increase by six times that at the present, the access should also be kept in future.

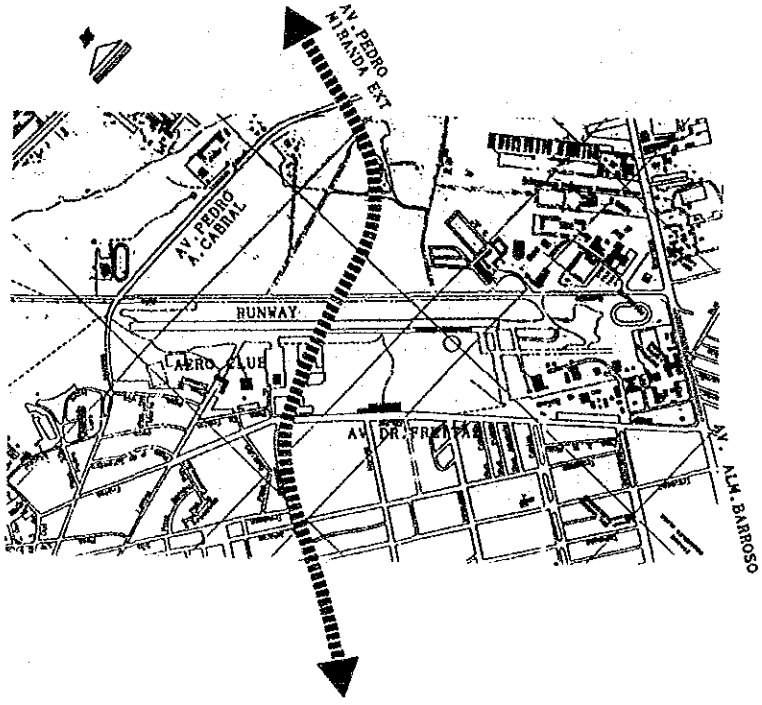


Figure 11.2-4 Project of Av. Pedro Miranda Extension

(8) Rodvia Aura (R09)

509. The Cidade Nova housing estate has a main access to BR-316 via Rodvia do Coqueiro (two lanes) at present, and the traffic congestion is anticipated on this road in the future when the area along Rodvia do Coqueiro will be developed as residential area. Therefore another access is planned extending the existing divided four lanes local artery which runs within the estate diagonally, to BR-316 and beyond BR-316 to the east up to Aura area to secure the access from this area to BR-316 and the extension of Av. 1o de Dezembro as well and to be an axis of development in future.

(9) Rodvia Industrial (R10)

510. This road is planned to be a main access to the industrial area in Ananindeua and at the same time is expected to be a local artery linking the future residential area of Aura, Curucamba and Icui-Guajara. The road runs along the periphery of these residential area. The entire length will be 13.4 Km.

(10) Local Arteries in Satelite Area (R11)

511. The Satelite and the neighboring Maguari housing estates have their main accesses to Av. Augusto Montenegro at present, however another accesses to the adjacent area will be needed along with the development in this area in future. Therefore, the local arteries are planned to be located at every two Kms. The entire length will be 4.6Km.

(11) Icoaraci Bypass (R12)

512. The two trunk roads of Av. Augusto Montenegro and Av. Arthur Bernardes meet in the built-up area of Icoaraci at present, and the traffic from the Icoaraci Industrial area at the north of Icoaraci is enforced to pass through this area. The Icoaraci Bypass is planned to lead the residential development to the suburban area of Icoaraci together with the construction of PA-150 and to channel the through traffic in Icoaraci to the Bypass.

(12) Local Arteries related with Cidade Nova (R13)

513. The construction of the trunk roads of Rodvia Belem and PA-150 in the present undeveloped area requires the construction of local arteries in Cidade Nova, Curucamba, and Icui-Guajara area. These local arteries are planned to be located at every 2Km and taking the existing land blocks into consideration. The entire length will be 5.8Km.

(13) Estrada do 40 Horas (R14)

514. The existing Estrada do 40 horas road is the only paved road diverted from Rodvia do Coqueiro to go to the north in Curucamba area. The project will extend this road up to PA-150, when PA-150 is constructed in the future, to be an artery to the residential development area. At the same time, the existing branch roads from the 40 Horas road is planned to be paved to serve as the local arteries within the residential area. The entire length will be 3.6Km.

(14) Av. Alcindo Cacella / Tv. 9 de Janeiro (R15 and R16)

515. Av. Alcindo Cacella is only a two-way road running in a north-south direction in the central area at present. Tv. 9 de Janeiro, which runs parallel with Av. Alcindo Cacella, has been planned to form a pair of one-way roads in BMR, and the plan followed this idea. Both sections of Tv. 9 de Janeiro from Av. Nazare are paved to some extent, however at around the intersection with Av. Padre Eutiquio in the south, even ROW is not secured. Near the intersection with Av. Pedro Miranda in the north, the road will pass the flood area of Una Rv. and the construction work requires the improvement of this river, then the road can be linked with Av. Bankoba Marques which runs parallel with Av. Pedro Miranda.

(15) Av. Bernardo Sayao (R17)

516. The present Av. Bernardo Sayao is two lanes two-way road running from Belem University to the micro Centro along Guama River. At the river side of the road, some ferry ports and small - medium size attached markets are located, while a canal is running in a parallel direction at the other side seriously preventing the free access from the adjacent area to the road. The project aims to widen the road to four lanes at the section from Belem University to the intersection with Av. Alcindo Cacella and to improve the canal to upgrade the living environment in Belem built up area.

(16) Inner Ring Road (R18)

517. The project consists of the construction of a road from the intersection with Av. Alcindo Cacella / Av. Pedro Miranda to the intersection with Pedro Cabral in the east, and a road to the intersection with Av. Bonifacio / Av. Doque de Caxias, to facilitate the circumferential road around the central area of the city. The total length will be 1.9Km.

(17) Extension of Tv. Humaita / Tv. Loma (R19 and R20)

518. The present Tv. Humaita and Trav. Loma, which run through the Pedreira and Sacramenta Districts in east- west direction, are unpaved in the west section from Av. Pedro Miranda and are interrupted by the existence of Una River. The parallel road which links to Av. Pedro Cabral or Av. Senador Lemos beyond the river is only Tv. Mauriti. The project is to extend both roads up to Av. Pedro Cabral to increase the function of the two roads as the semi-arteries in the built up area.

(18) Una River Road (R21)

519. Una River flows from the intersection with Av. Alcindo Cacella / Av. Pedro Miranda to Guajara bay crossing Sacramenta District diagonally and passing the north boarder of Telegrafo District. The river functions as urban drainage, and if it is improved, the land in Sacramenta District will be well drained. The project follows the idea to utilize the river side as the space for the traffic, which has been planned in BMR.

(19) Tv. 14 de Marco Extension (R22)

520. In Sacramenta District, there is no artery running in east-west direction because of flood by Una River. Therefore Tv. 14 de Marco, which is unpaved from the intersection with Pass. Fereira Pena at present, is planned to be an artery in this district by extending it up to Tv. Alferes Costa in parallel with Av. Pedro Miranda. The total extension will be 2.7Km.

11.3 Cost Estimate

11.3.1 Basic Conditions

(1) Foreign Currency Exchange Rate

521. The foreign currency exchange rate is set to 88 Cr$ to one US Dollar, which was the exchange rate in Oct. 1990 in free market.

(2) Salario Minimo

522. The minimum salary per month in Oct. 1990 was 6425.14 Cr$.

(3) BTN

523. The BTN (Bonus Tesouro Nacional) in Oct. 1990 was 66.6465 Cr$.

11.3.2 Wage

(1) Basic Salary

524. The basic salary by type of workers in terms of SMM (Salario Minimo Mensual) and in Cr$ was set as shown in Table 11.3-1.

Table 11.3-1 Basic Salary by Labor Classification

Classification	SMM	CR$/M
1. Driver	4.0	25,701
2. Foreman	6.0	38,551
3. Operator	4.5	28,913
4. Skilled Labor	2.0	12,850
5. Unskilled Labor	1.0	6,425

(2) Annual Working Hours

525. Annual working hours are estimated based on the following conditions;

a. The weekly working hour was assumed as 35 hours based on 7 hours a day and 5 days a week from Monday through Friday.
b. The sum of the annual national and state holidays was counted to 20 days in 1990, including the end-of-year,

new year and the carnival holidays.

c. The annual paid holidays (vacation) other than sick leaves for the permanent staff was regulated as one month.

d. The non workable days caused by rain or any climatic disaster is not applicable in Belem area throughout a year.

e. Based on the above conditions, the annual working hours was calculated as 1585 hours excluding overtime.

(3) Social Charges

526. Social charges are calculated on the following basis and the resulted amounts by labor classification are shown in Table 11.3-2.

Table 11.3-2 Social Charge by Labor Classification

Classification	Social Charge(%)
1. Driver	26.0
2. Foreman	26.7
3. Operator	18.3
4. Skilled Labor	16.7
5. Unskilled Labor	8.0

a. Income Tax (IRRF)

- The amount of IRRF was set at 10% and 25% of the basic salary, when it exceeds 38,989.00 Cr$ and 126,628.00 Cr$ a month respectively,deducting 3,798.90 Cr$ and 3,660.00 Cr$ per dependent.
- The composition of labor by single, with one dependent, and two dependents are assumed as 20%, 50% and 30% respectively.
- The whole amount of IRRF should be paid through the employer.

b. Labor Insurance (IAPAS)

- The amount of IAPAS is set at 8%, 9% and 10% of the basic salary.
- The whole amount of IAPAS should be paid by the employer, when the employee is the permanent staff.

c. Retirement Fund (FGTS)

- The amount of FGTS is set at 8% of the basic salary.
- The whole amount should be paid by the employer, when the employee is a permanent staff member.

d. Family Allowance

- The family allowance is set at 86.13 Cr$ a month for one dependent.
- The composition of labor by single, with one dependent, and two dependents are assumed as 20%, 50% and 30% respectively.
- The whole amount of Family Allowance is paid by the employer.

(4) Bonus

a. The bonus, which is called as thirteenth month, amounts at one month salary.
b. An additional 1/3 of the basic salary is regulated to be paid, when the employee takes an annual vacation.
c. The sum of the Bonus is calculated at 9.4% of the basic salary.

(5) Shadow Wage Rate

527. The shadow wage rate of 85% is applied to calculate the economic cost of unskilled labor (temporary worker) based on the unemployment rate of 8%.

(6) Hourly Wage

528. The hourly wage by labor classification including social charges, etc. is summarized in Table 11.3-3.

Table 11.3-3 Summary of Wage by Labor Classification

Description	Unit	Basic Salary (CR/HR)	Social Charge (%)	Overtime (H/M)	Overtime (%)	Financial Foreign (US$)	Financial Local (CR$)	Economic Local (CR$)
Driver	hour	213	26.0	30	1.5	0.00	293	232
Foreman	hour	319	26.7	30	1.5	0.00	442	349
Operator	hour	239	18.3	30	1.5	0.00	309	262
Skilled L.	hour	106	16.7	30	1.5	0.00	136	116
Unskilled L.	hour	49	8.0	30	1.5	0.00	57	45

11.3.3 Material Cost

529. The material cost in terms of financial cost is referred to "Consturucao Sept. 1990". The foreign currency portion is assumed as shown in Table 11.3-4 for some imported goods as petroleum products. To calculate the economic costs of the material, 17% of sales tax (ICMS) is assumed.

Table 11.3-4 Provision of Foreign Portion

Description	Provision of Foreign Portion
Asphalt 80-100	80.0 %
Asphalt Emulsion-2	80.0
Cement	30.0
Concrete Pole	10.0
PC Materials	50.0
PC Pile	20.0
RC Pile	20.0

11.3.4 Equipment Cost

530. The equipment cost was calculated as the sum of the depreciation, maintenance cost, repairing cost, and operating cost (fuel and lubricant cost). The annual operating hour and the operating life are decided by reference to other countries. The residual value of the equipment at the end of the operating life is assumed as 10% of the basic price.

531. No foreign currency portion of the equipment is assumed because of high nationalization rate of the equipment of 80% - 100% according to information from a heavy equipment production company (Table 11.3-5).

Table 11.3-5 Nationalization of Heavy Equipment

Description	Nationalization Weight(%)	Price(%)
1. Bulldozer D8	83.65	82.68
2. Wheel Loader 930R	97.59	94.19
3. Motor Grader 120B	99.16	98.80
4. Motor Grader 140B	99.20	98.91
5. Scraper 621	85.88	83.90
6. Scraper 631	74.06	79.06

532. The domestic market price of equipment includes many kinds of taxes, and the international price is applied to eliminate these transfer costs and to reach to the economic cost of equipment.

11.3.5 Unit Costs

533. The unit costs by work item are calculated on the basis of standard productivity of labor and equipment, and combining these costs with the costs of necessary materials.

11.3.6 Land acquisition and Compensation Cost

534. Figure 11.3-1 shows the land price in BMR in Oct. 1990, which was obtained from the real estate broker. The land price in Batista Campos is the highest at 35,000 Cr$/SQM and that in Curucamba is the lowest at 100 Cr$/SQM.

535. The relocation cost for the high tension transmission line is assumed as 6 million Cr$ per tower.

11.3.7 Indirect Cost

536. Indirect cost includes costs for preparatory works, temporary works, overhead, administration cost of contractors, etc. The indirect cost varies depending on the environmental conditions of the construction sites, contract size, contract condition, etc. Therefore 30% of direct cost excluding land acquisition cost is assumed at this stage, 30% of which is assumed to be foreign currency portion.

11.3.8 Cost of Engineering Services

537. Engineering service cost is assumed at 12% of the sum of the direct cost excluding land cost and indirect cost, 30% of which is assumed to be foreign currency portion.

11.3.9 Contingency

538. Contingency is assumed at 10% of the sum of direct cost, indirect cost and engineering services. The foreign and local currency portion are allocated in proportion to the individual sum.

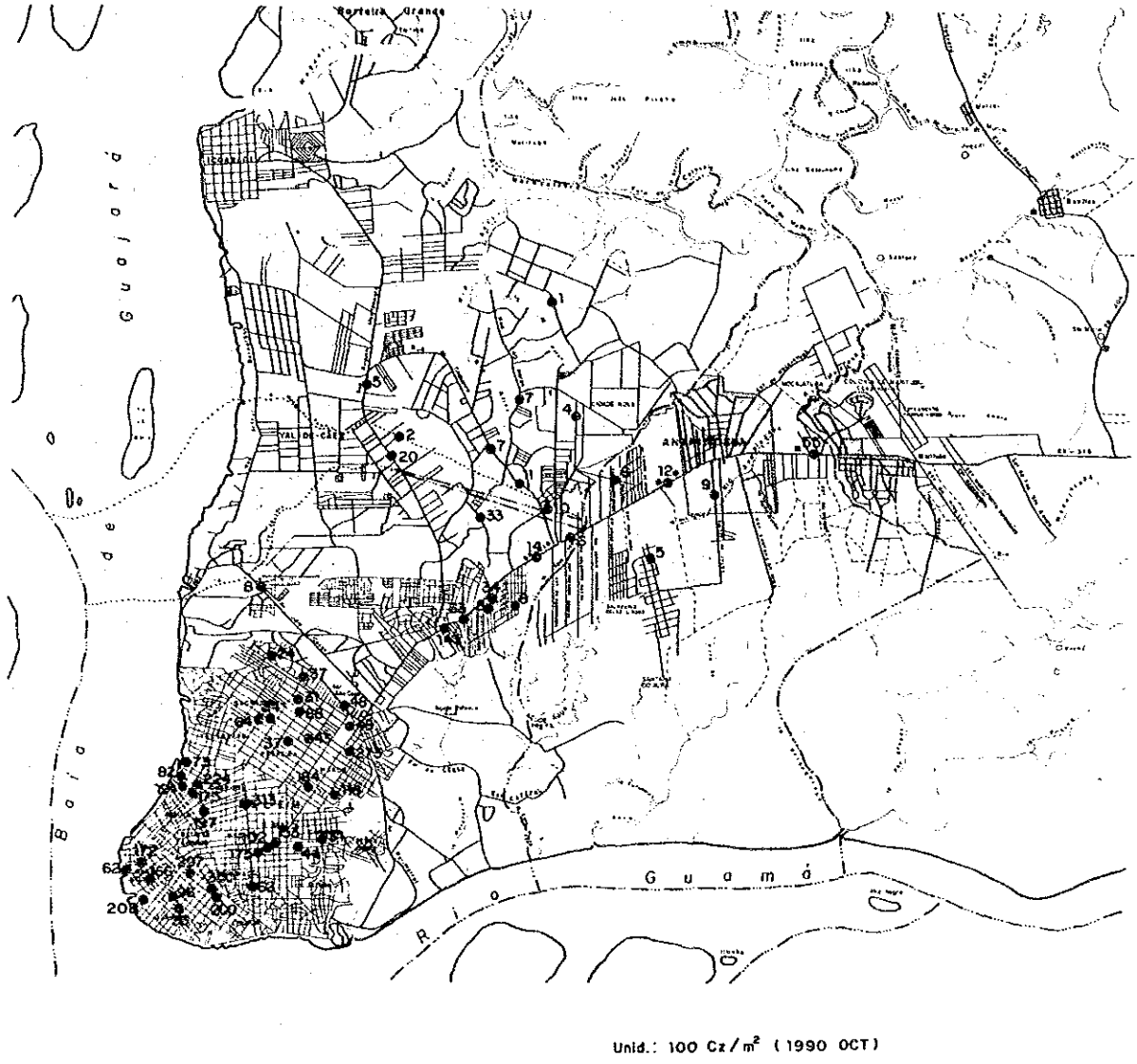


Figure 11.3-1 Land Price in BMR