Outdoor parking lots; 2,340 m^2 (for 78 vehicles)

b. Chambacu area (14.1 ha, only Zone II)

b-1 Sector I (Multi center, 13.1 ha)

b-1-1 Sector I-A (Commercial, 6 ha)

Site area ; 60,000 m^2
Building area ; 15,000 m^2 (building coverage 25%)
Total floor area ; 60,000 m^2 (4 stories)
Area of store space; 36,000 m^2 (60% of total floor area)
Number persons engaged; 1,200 persons (30 m^2 per person)
Number of parking lots; 1,800 lots (1 for each 20 m^2 store space)
Area of parking lots; 54,000 m^2 (30 m^2 per lots)
Parking building (capacity, 1,320 vehicles)
Total floor area, 39,600 m^2, 4 stories (9,900 m^2 per story)
Outdoor parking lots, 14,400 m^2 (for 480 vehicles)

b-1-2 Sector I-B (Residential, 7.1 ha)

Site area ; 71,000 m^2
Building area ; 17,750 m^2
Total floor area ; 355,000 m^2 (20 stories, floor area ratio 500%)
Total area of dwelling units; 248,500 m^2 (70% of total floor area)
Number of dwelling unit; 1,775 units (140 m^2 per unit)
Number of inhabitants; 7,100 persons (4 persons per unit)
Population density; 500 psn per ha for total project site
1,000 psn per ha for Sector I-B
Number of garages and parking lots;
1,775 garages for residents (1 for each)
178 lots for visitors (1 for 10 units)
Area of garages and parking lots;
Indoor garage for residents; 26,640 m^2 (2 stories building)
Outdoor garage for residents; 26,610 m^2
Outdoor parking lots for visitors; 5,340 m^2
Area of recreational space for community use;
17,750 m^2 (5% of total floor area)

b-2 Sector II (Centro Administrativo, 1.0 ha)

Site area ; 10,000 m^2
Building area ; 4,000 m^2 (building coverage 40%)
Total floor area ; 40,000 m^2 (10 stories)
Area of office space; 30,000 m^2 (75% of total floor area)
Number of persons engaged; 2,000 persons (15 m^2 per person)
Number of parking lots; 600 units (1 for each 50 m^2 office space)
Area of parking lots; 18,000 m^2 (30 m^2 per lot)
Indoor parking lot; 15,960 m^2 (4 stories)
Outdoor parking lot; 2,040 m^2 (for 68 visitors)

c. Maritime Terminal (39.5 ha)

c-1 Residential Sector (10 ha, 10 buildings)

- for each building

Building area ; 3,500 m^2 (building coverage 35%)
Total floor area ; 28,000 m^2 (8 stories, floor area ratio, 280%)
Total area of dwelling units; 20,000 m^2 (71.4% of total floor area)
Number of dwelling units; 125 units (160 m^2 per unit)
Number of inhabitants ; 500 persons (4 persons per unit)
Net population density ; 500 persons per hectare
Number of garages and parking lots;
125 garages for residents (1 per unit)
36 parking lots for visitors (3 per each 10 units)
Area of garages and parking lots;
Indoor garage for residents; 3,750 m^2 (1 story, 30 m^2 each)
Outdoor parking lot for visitors; 1,080 m^2 (30 m^2 per lot)
Area of recreational space for community use; 1,400 m^2 (5% of total floor area)

c-2 Commercial/business Sector (13.5 ha)

Total floor area ; 387,500 m^2
Area of store and office space; 290,000 m^2 (75% of total floor area)
Number of persons engaged; 11,600 persons (25 m^2 per person)

c-3 Educational Sector (12.0 ha)

Number of students; 8,000 students (15 m^2 per person)
Number of teachers/officials; 400 persons (1 for each 20 students)

note: According to the municipal standard, the minimum site area unit is 13 m^2 per student. Existing school data show the number of staff is some 1/30 of students.

c-4 Green Sector (4.0 ha)

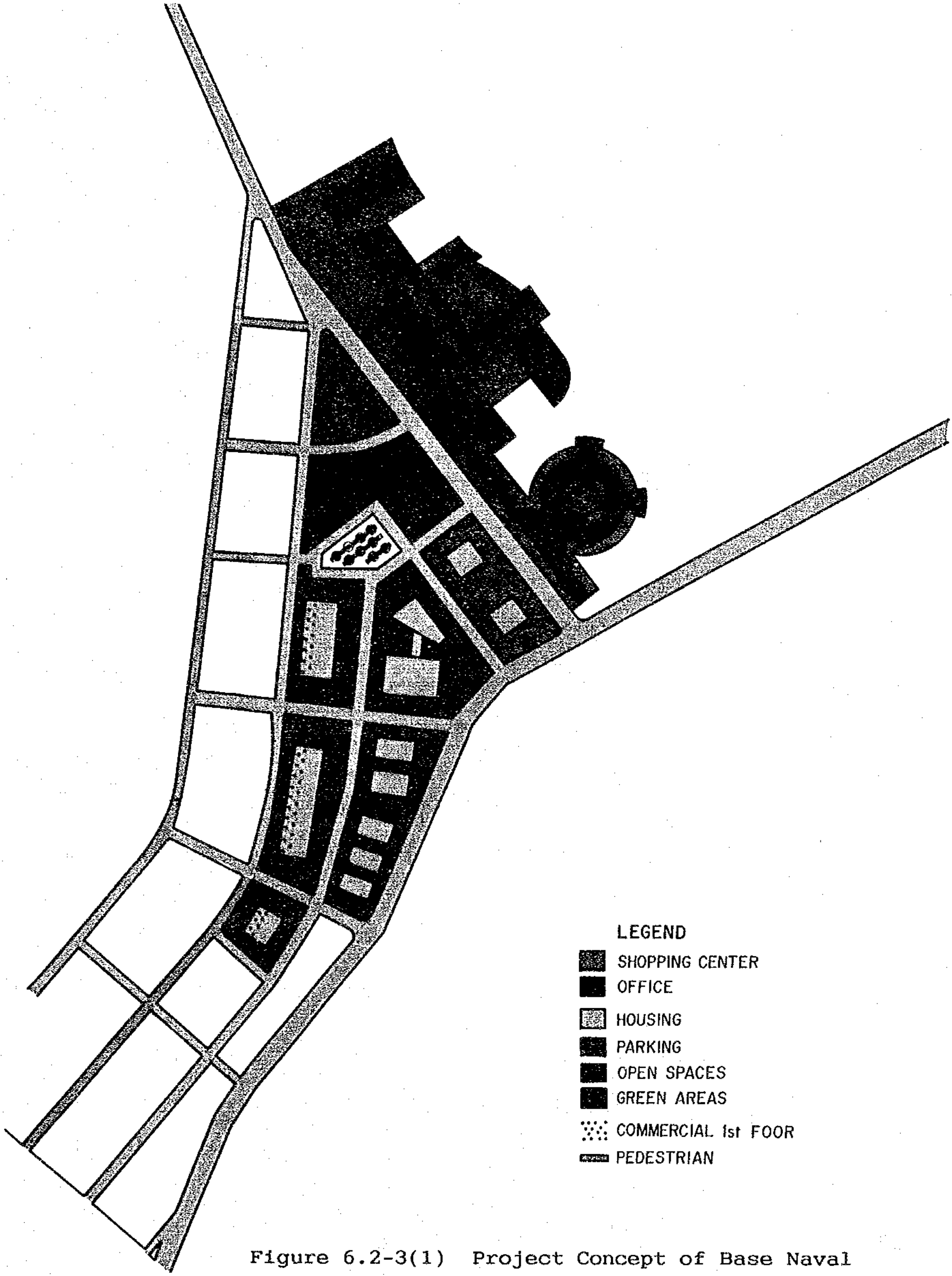


Figure 6.2-3(1) Project Concept of Base Naval

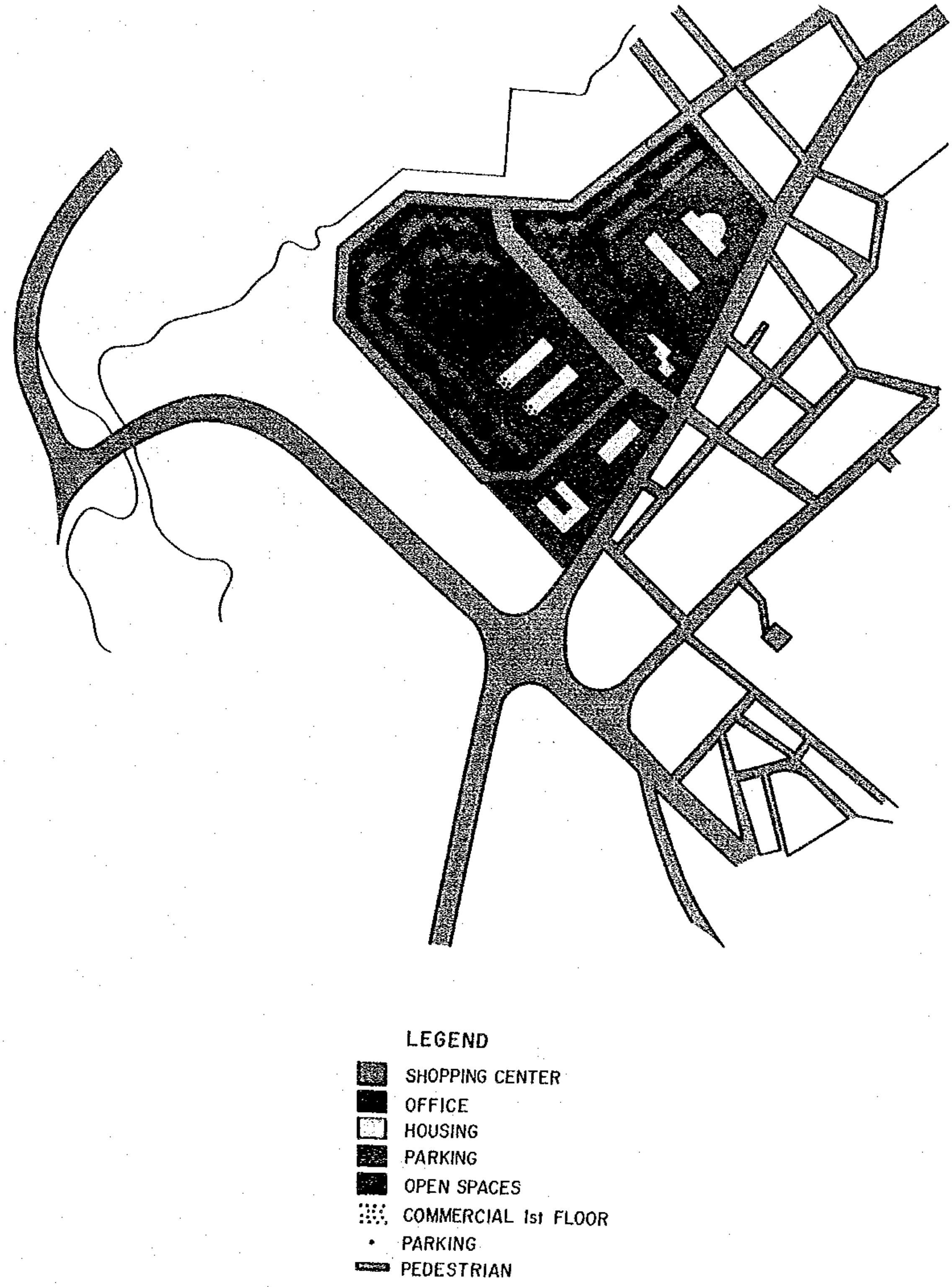


Figure 6.2-3(2) Project Concept of Chambacu

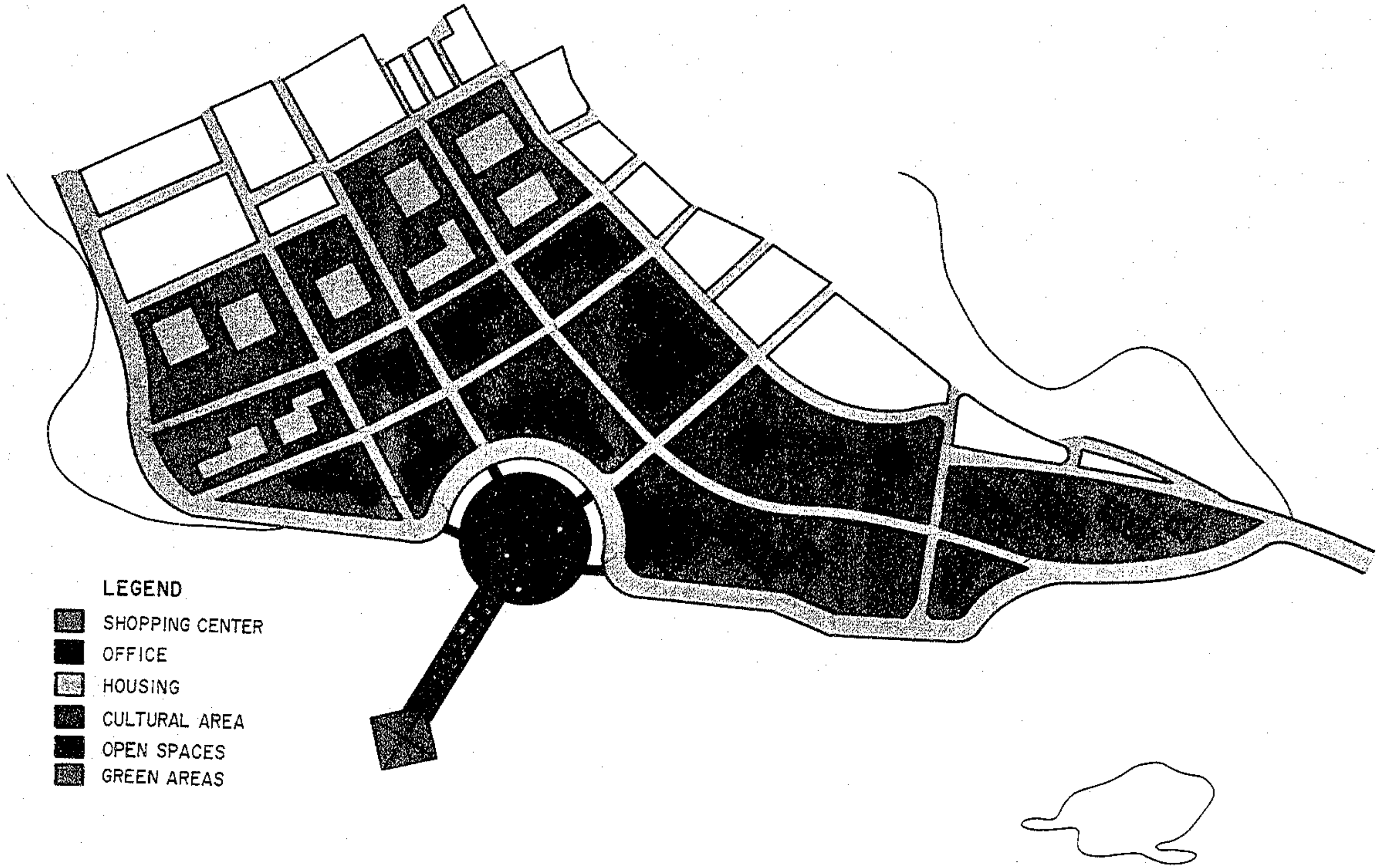


Figure 6.2-3(3) Project Concept of Terminal Maritimo

6.3 Future Vehicle Ownership

6.3.1 General

466. Current vehicle ownership in the Study Area is at a fairly low level. In 1990, the ratio per thousand inhabitants is only 32.6 for the total of passenger cars, taxis and trucks. However, its growth rate for last decade recorded high rate (refer to Table 6.3-1).

Table 6.3-1 Vehicle Number Registered in Study Area

Year	Pass.Car	Taxi	Truck	Total
1981	5,131	539	1,324	6,994
1982	6,273	695	1,599	8,468
1983	7,119	844	1,591	9,554
1984	7,888	975	1,702	10,565
1985	8,844	1,084	1,874	11,802
1986	9,774	1,261	2,052	13,087
1987	10,195	1,338	2,073	13,606
1988	11,710	1,772	2,287	15,769
1989	13,680	2,276	2,539	18,495
1990	15,924	2,777	2,842	21,543
1991*	16,944	2,872	2,902	22,718
Growth Rate (%/annum)	13.4	20.0	8.9	13.3

note: Data in 1991 is registered number until July.
Growth rate is average between 1981 and 1990.

467. As described in section 2.3, the passenger car ownership is generally limited to the relatively higher income group due to the high car prices of new cars as well as used cars. Depending on the market prices in 1991, the car prices are roughly as shown in Table 6.3-2.

Table 6.3-2 Market Car Prices (million pesos)

Type	Engine Capacity	Price
New Car	1.3 - 2.0 liters	9.0 -14.0
Used Car		
5 years	1.3 - 2.0 liter	4.0 - 7.0
10 years	1.3 - 2.0 liter	2.0 - 3.5

468. Taking into consideration the household income structure in the Study Area, about 60 per cent earn less than 150 thousand pesos per month based on the Home Interview Survey Result, low car ownership is understandable (refer to Table 6.3-3). However, non-car owning households belonging to upper-middle and high income groups still exist and therefore such households are

forecasted to own cars in near future.

Table 6.3-3 Income Structure and Car ownership

Income Rank	No. of Households	Non-car (%)	One-car	Multi-car
50,000	20,213	19,972(99)	241	0
75,000	26,289	25,772(98)	517	0
100,000	26,178	25,459(97)	719	0
150,000	18,569	17,401(94)	1,168	0
200,000	12,783	11,502(90)	1,281	0
250,000	7,034	5,891(84)	1,143	0
300,000	5,195	3,727(72)	1,289	179
400,000	3,127	2,084(67)	842	201
600,000	2,331	1,194(51)	857	280
700,000	1,099	488(44)	431	180
900,000	1,507	555(37)	644	308
1,000,000	1,151	0	786	365
over	1,429	0	756	673
Total	128,905	114,045	10,674	2,186

source: Home Interview Survey results, August, 1991
note : The values of income are not rigorous ones because of the limitation of survey method.

6.3.2 **Forecast of Future Vehicle Ownership**

(1) Passenger Car

469. Presuming no drastic changes in car prices and social income structure in the Study Area, the car ownership will increase according to the sum of population increase and income growth, if supposing the appropriate households will purchase the car. The actual car ownership in the Area is at low level compared with other cities, therefore, it will increase at high growth rate following that as in past decade.

470. Table 6.3-4 shows the forecast of passenger car ownership growth for next two decades based on the population growth, income growth and past growth rate of car ownership of the Area.

Table 6.3-4 Forecast of Car Ownership of the Area

Year	1981	1990	1995	2000	2005	2010
No. of Pass. Car	5,131	15,924	25,640	37,670	50,410	67,460
Growth Rate (%)		13.4	10.0	8.0	6.0	6.0
Pop. Increase(%)		4.1	3.2	3.1	2.9	2.9
Income Growth(%)		-	1.3	2.1	2.3	2.3
Ownership (veh./1000 psn)	-	24.1	33.2	41.9	48.5	56.2

note: Population increase and income growth correspond to the forecast of Chapter 6.

471. In 2010, more than 20 % of households will have private cars in contrast to 10 % at present.

(2) Taxi

472. Taxi is used as a part of public transport in the Area. Number of taxi trips in 1991 is about 52,480 per day in Cartagena which corresponds to 4.2 % of the total person trips exclusive of walking trips. One taxi make 18.9 trips per day on the average.

473. Number of taxi vehicles has increased at very high rate for last decade (refer to Table 6.3-1). The increase is due to;

a. low private car ownership,
b. small number of taxi vehicles, and then
c. attractive business with relatively little investment.

474. Since the condition of private car ownership is difficult for the middle and low income people, the taxi business is attractive, and the number of taxi vehicles will increase until the moderate level of operation is reached. The moderate level of taxi vehicles is very difficult to determine, however assuming about 7 % of the total person trips by taxi, the number of taxi vehicles is forecasted as shown in Table 6.3-5.

Table 6.3-5 Forecast of Taxi Vehicles

Year	1990	1995	2000	2005	2010
Population (1000 psn)	660	773	900	1,040	1,200
Total Trip Number (1000)	1,254	1,469	1,710	1,976	2,280
Taxi Share (7 %)	88	103	120	138	160
No. of Taxi by 7 %	4,660	5,450	6,350	7,300	8,470
No. of Taxi forecasted	2,777	4,890	6,240	7,230	8,420
Growth rate (%)	20.0	12.0	5.0	3.0	3.1

note: No. of taxi by 7 % is calculated by assuming 18.9 trips of the average trips per day.

(3) Truck

475. The growth of truck number is considered due to the population growth and economic growth. Based on the past decade growth of such factors, following model can be obtained;

Growth rate of number of truck: 8.9 % per annum from 1981 to 1990
Population growth: 3.3 % per annum from 1985 to 1990
GDP growth: 4.4 % per annum from 1985 to 1990
Elasticity of growth rate of truck vehicle number
to the sum of those of population and GDP:
1.089/1.077 = 1.011

476. Using this elasticity, the number of truck vehicles is forecasted as shown in Table 6.3-6.

Table 6.3-6 Forecast of Truck Vehicles

Year	1990	1995	2000	2005	2010
Pop. Growth (% per annum)		3.2	3.1	2.9	2.9
GDP Growth (% per annum)		4.3	4.5	4.5	4.5
Growth Rate of Truck (%)		8.7	8.8	8.6	8.6
No. of Truck Vehicles	2,842	4,310	6,570	9,920	14,990

note: Growth rates of population and GDP correspond to the result of Chapter 6.

477. Total vehicle number forecasted exclusive of bus and motorcycle is summarized in Table 6.3-7.

Table 6.3-7 Vehicle Forecast in the Study Area by 2010

Year	1990	1995	2000	2005	2010
Passenger Car	15,924	25,640	37,670	50,410	67,460
Taxi	2,777	4,890	6,240	7,230	8,420
Truck	2,842	4,310	6,570	9,920	14,990
Total	21,543	34,840	50,480	67,560	90,870
Ownership per 1000 inhabit.	32.6	45.1	56.1	65.0	75.7

CHAPTER 7 FUTURE TRAVEL DEMAND

7.1 General

478. In this Study, Vehicle OD Trip Survey was carried out instead of Person Trip Survey. An advantage of this survey method is not only to reduce the survey volume, but also make it easy for data analysis. However, by Vehicle OD Trip Survey, it is difficult to arrive at the relationship between private and public modes. Therefore, several surveys, including Household Characteristic Survey and Public Transport Survey, were conducted in this Study to supplement the above information.

479. In Cartagena, it was disclosed from the data analysis that car ownership influences the determination of modal choice between private car and public bus. It is not likely that the modal choice is made by the travel time or travel cost on the route to destination.

480. In this Study, taking into consideration the survey method and the trip characteristics such as demand structure and modal choice, the urban travel demand model was made.

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

482. For the modal split model, the model known as a "trip-end" model was employed. This model is based on the assumption that modal choice is primarily explained by socioeconomic characteristics on generated or attracted zone. The variables used in this model are car ownership and income, etc. This model, however, can not utilize the service characteristics (travel times, costs, etc.) of the alternative modes to determine the modal splits. In Cartagena, as before-mentioned, the modal choice between private car and public bus is primarily determined by whether the passengers are car owners or not, and not by the travel time or cost.

483. The flowchart of forecasting model is shown in Figure 7.1-1. The model is embodied by mode corresponding to each step as shown in Table 7.1-1. As for trip purpose, this was classified into all purposes exclusive of "to home" purpose and "to home" purpose.

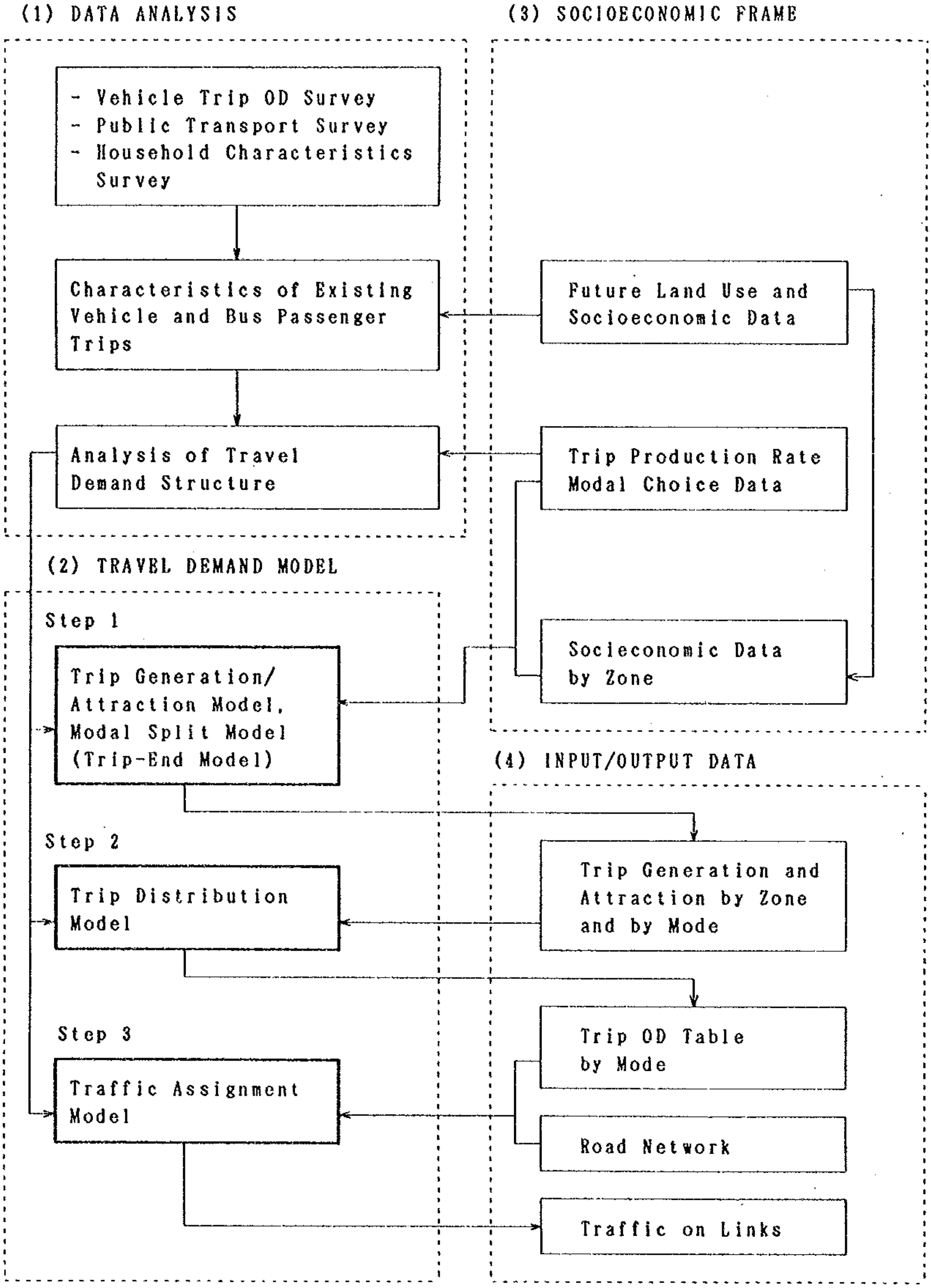


Figure 7.1-1 Flowchart of Forecasting Model

Table 7.1-1 Model Structure

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

484. 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 their trips to the total is as low as 4% at present. The influence on the accuracy of estimated whole trips is little, even when the simple method is employed for non-residents.

485. The forecasting of future truck demand was made by the similar simple estimation method as that forecasted for the non-residents, not by applying the four step method. This is because at present, truck trip ratio to the total represents (2%) of the urban traffic.

486. The classifications of trip purpose and transportation modes are shown below;

a. Trip Purpose

- To work/to school/business/private
- To home

b. Classification of Modes

- Car
- Taxi
- Bus
- Truck

7.2 Travel Demand Model

7.2.1 Trip Generation and Attraction Model

487. This model has two steps: the first is to estimate the total trip production for an entire area, and the second is to estimate zonal generated and attracted trips which are adjusted into agreement with the total trip production as control total. At the same time, modal choice is made by zone based on the trip end model.

(1) Trip Production

488. Future total trip production in the Study Area was estimated by using future trip production rate (number of trips per person). Since the motorization (number of cars per 1000 persons) and production rate have some relationship in which the higher the motorization is, the higher the trip production from the data analysis, the relation as shown in the following equation was employed to estimate the future trip production rate.

$$Log(PR) = a + b * Log(M)$$

where;

PR : Trip Production Rate
(Car+Taxi+Bus)trips per population (above 5 years old)
M : Motorization (number of cars per 1000 population)
a = -0.2288
b = 0.2559

(2) Trip Generation and Attraction Model

489. Trip generation and attraction by zone are forecasted by trip purpose and by mode as before-mentioned. This model also has two steps: the first is to estimate the zonal trip generation by all modes, and the second is to estimate the modal choice between private (car and taxi) and public bus. As for "to home" purpose, the trip generation is reflected as the total sum of attracted trips of other purposes. On the other hand, the trip attraction is considered as the total sum of generated trips in the same manner.

490. As for the modal split, the transportation modes are classified into 2 modes: private transport (car and taxi) and public transport (bus). The estimation of each transport mode is made by the trip end model. In this classification, taxi is classified into private mode due to the fact that taxi serves as private due to its nature similar to passenger cars.

491. The forecasting of trip generation is estimated by the

following steps:

1) Future zonal trip generation rate is estimated by using the equation below;

$$GRi = K / (1 + a * e^{-(b * Mi)})$$

where;

GRi = Trip generation rate of zone i
purpose: all purpose exclusive of "to home" purpose)
mode : (Car+Taxi)trips per population (above 5 years old)

Mi : Motorization of zone i (number of cars per 1000 population)

K = 1.7
a = 25.2700
b = 0.0295
r = 0.93

2) Future zonal trip generation is estimated below;

Trip generation of zone i = GRi * population (above 5 years old)

3) Future zonal modal choice is estimated by the trip end model as shown in the following equation. Car ownership by each zone was employed as the variable in this model. The relationship with this variable is shown in Figure 7.2-1.

$$PVTi = a + b * Log(Mi)$$

where;

PVTi : Ratio of modal choice by private car including taxi
Mi : Motorization of zone i (number of cars per 1000 population)
a = -0.157
b = 0.121
r = 0.96

4) As for trip attraction, linear type regression models were developed. The equation is shown below;

$$Aj = a + b1*Xj1 + b2*Xj2 + b3*Xj3$$

where;

Aj : Attraction trip to zone j
Xj : Socioeconomic data in zone j
a, b1, b2, b3: model parameters (refer to Table 7.2-1)

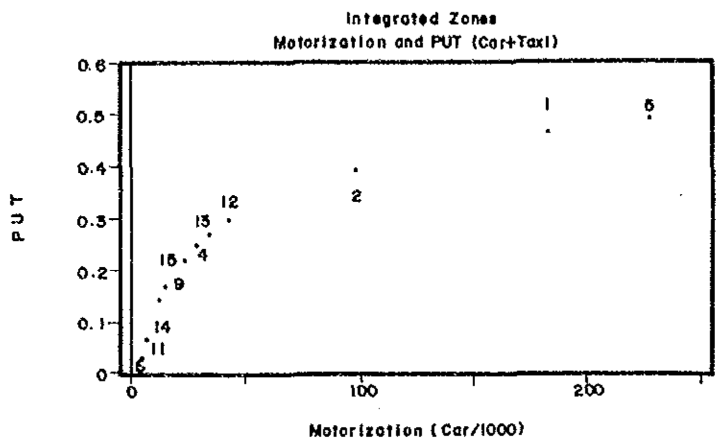


Figure 7.2-1 Relationship between Motorization and PVT

Table 7.2-1 Parameters of Trip Attraction Model

Items	a	b1	b2	b3	r
(a) Car+Taxi					
All purpose (excluding "to home")	-458.2	0.630	-	6968.9	0.93
(b) Bus					
all purpose (excluding "to home")	-6129.0	2.086	1.706	78661.5	0.95

note: variables

(a) Car+Taxi X1 : employment on working place (first, second and tertiary)
X3 : dummy = 1

(b) Bus X1 : employment on working place
X2 : students on school place
X3 : dummy = 1

492. Since there are some gaps on the several zones between estimated values and actual data, dummy variable is added in this model to improve the accuracy of estimation.

493. As for the estimation of taxi trips, the split ratio of taxi and car is applied based on the present trip ratio using taxi by each zone from the Vehicle OD Trip Survey data. Based on this, the taxi trip generation and attraction are estimated.

7.2.2 Trip Distribution Model

494. Voorhees-type gravity models are developed to estimate interzonal trips by all purposes exclusive of "to home" purpose and by mode. The "to home" trip is estimated in the same manner as generated and attracted "to home" trip.

(1) Interzonal Trips

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

where;
- Tij : OD trips between zone i and j
- Gi : Generated trips from zone i
- Aj : Attracted trips to zone j
- Dij : Road time distance between zone i and zone j (minutes)
- a : Parameter (refer to Table 7.2-2)

Table 7.2-2 Parameter of Trip Distribution Model

Type of Vehicle		a	r
(1)	Car	-0.535	0.985
(2)	Bus	-0.400	0.917

Note: All purposes exclusive of "to home" purpose

(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 (ha)
- Di : Dummy variable
- K, a, b, c, d : Parameters (refer to Table 7.2-3)

Table 7.2-3 Parameters of Intrazonal Model

Type of Vehicle		K	a	b	c	d	r
(1)	Car	0.0191	0.2370	0.6207	0.3332	2.0812	0.89
(2)	Bus	0.0319	0.6705	0.1759	0.3177	2.2446	0.96

note: All purposes exclusive of "to home" purpose

7.2.3 Truck Demand Model

495. The truck demand is estimated by a simple estimation method based on trend analysis. The method has two steps; the one is to estimate the traffic demand corresponding to the future growth of truck or cargo volume, the other is to estimate the generated and attracted volumes from/to large scale industrial projects in the future.

496. The trip production rate of truck is estimated by traffic volume per the employed population of secondary sector at present. The future traffic volume is forecasted based on the future number of truck and secondary workers.

7.2.4 Traffic Assignment

497. 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, taxi and truck on roads, where the private vehicle passes on minimum distance/time route chosen in this model, and the other is for public transport (bus and water transport) on fixed routes. The buses and boats 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.

498. Bus assignment is conducted by the bus assignment model in which bus passengers are assigned on bus routes applying the minimum distance chosen from among several bus routes to connect same OD pair. This model is employed in the planning to introduce public water transport system, in which the diverted passengers from alternative bus routes to water transport routes is estimated.

(1) Average Occupancy and PCU

499. The person base trip OD tables (trip/person) by mode have to be modified into passenger car unit (trip/PCU). These OD tables are 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 7.2-4.

Table 7.2-4 Average Occupancy and Passenger Car Unit (PCU)

Vehicle Type	Average Occupancy	PCU Factor
Car	1.85	1.0
Taxi	1.62	1.0
Truck	2.26	2.5
Bus	24.62	2.0

(2) Traffic Assignment Model for Private Mode

500. 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.

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 7.2-2 and Table 7.2-5 show the speed-flow curves.

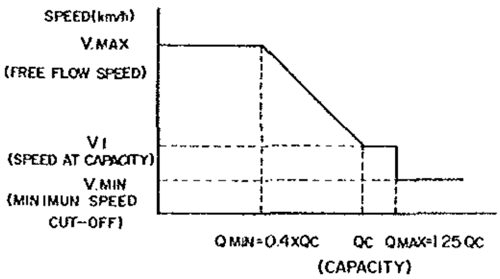


Figure 7.2-2 Typical Speed/Flow Curve

Table 7.2-5 Speed-Flow Curves

No.	Landuse	Road Classif	Conditions: Paved or Unpaved	Conditions: 1-way or Dual-way	Conditions: No. of Lanes	Speed: Vmax (km/hr)	Speed: V (km/hr)	Speed: Vmin (km/hr)	Capacity: Q1 (veh/hr)	Capacity: Qc (veh/hr)	Capacity: Qmax (veh/hr)
1	Urban Area	Major Road	1	2	8	96	80	10	38,400	96,000	120,000
2			1	2	6	96	80	10	28,800	72,000	90,000
3			1	2	5	96	80	10	24,000	60,000	75,000
4			1	2	4	96	80	10	19,200	48,000	60,000
5			1	2	2	84	70	8	6,400	16,000	20,000
6			1	2	1	78	65	5	3,200	8,000	10,000
7			1	1	6	96	80	10	28,800	72,000	90,000
8			1	1	5	96	80	10	24,000	60,000	75,000
9			1	1	4	96	80	10	19,200	48,000	60,000
10			1	1	3	96	80	10	14,400	36,000	45,000
11			1	1	2	84	70	8	9,600	24,000	30,000
12			1	1	1	78	65	5	4,800	12,000	15,000
13		Minor Road	1	2	8	72	60	8	38,400	96,000	120,000
14			1	2	6	72	60	8	28,800	72,000	90,000
15			1	2	4	72	60	8	19,200	48,000	60,000
16			1	2	2	48	40	5	6,400	16,000	20,000
17			1	2	1	42	35	5	3,200	8,000	10,000
18			1	1	4	72	60	8	19,200	48,000	60,000
19			1	1	3	72	60	8	14,400	36,000	45,000
20			1	1	2	48	40	5	9,600	24,000	30,000
21			1	1	1	42	35	5	4,800	12,000	15,000
22			2	2	4	36	30	5	14,400	36,000	45,000
23			2	2	2	36	30	5	4,800	12,000	15,000
24			2	2	1	24	20	5	3,200	8,000	10,000
25		Access Road	1	2	4	48	40	5	15,360	38,400	48,000
26			1	2	2	36	30	5	5,120	12,800	16,000
27			1	2	1	30	25	5	2,560	6,400	8,000
28			1	1	4	48	40	5	15,360	38,400	48,000
29			1	1	3	36	30	5	11,520	28,800	36,000
30			1	1	2	36	30	5	7,680	19,200	24,000
31			1	1	1	30	25	3	3,840	9,600	12,000
32			2	2	4	24	20	5	11,520	28,800	36,000
33			2	2	2	24	20	5	3,840	9,600	12,000
34			2	2	1	18	15	3	2,560	6,400	8,000
35	Sub-Urban		1	2	8	96	80	10	38,400	96,000	120,000
36			1	2	6	96	80	10	28,800	72,000	90,000
37			1	2	4	96	80	10	19,200	48,000	60,000
38			1	2	2	72	60	8	6,400	16,000	20,000
39			1	2	1	36	30	5	3,200	8,000	10,000
40			2	2	8	36	30	5	30,720	76,800	96,000
41			2	2	6	36	30	5	23,040	57,600	72,000
42			2	2	4	36	30	5	15,360	38,400	48,000
43			2	2	2	24	20	5	5,120	12,800	16,000
44			2	2	1	12	10	3	2,560	6,400	8,000

Condition of Q-V Data

1) Road Surface; 1: Paved
2: Unpaved

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

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

501. Minimum bus route from among several alternative routes by OD pair is chosen taking into account a waiting time at bus stops when passengers transfer bus, and bus passengers are assigned on this route. This assignment system introduces the concept of traffic assignment model for private mode in which OD table is divided into several lots, and the assigned route is determined by each lot according to equilibrium equations between speed and capacity. In this model, 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 is not chosen in next lot.

502. This model associates with the planning to introduce the water public transportation against alternative bus transportations. The passengers will divert to boats from alternative bus

routes by time efficiency between both routes by each OD pair.

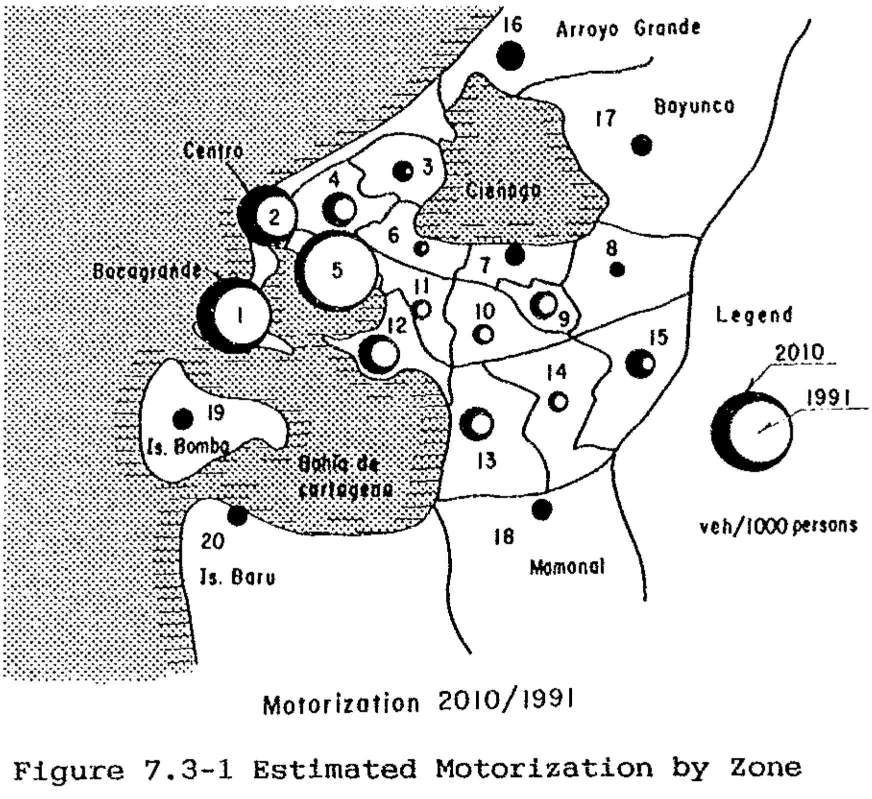
503. Method of the model is outlined as follows;

a. OD matrices are divided into the following 5 lots to make the phased assignment of the traffic: 1st 30%, 2nd 20%, 3rd 20%, 4th 20% and 10%.
b. Minimum distance route is selected on the assumption that minimum time bus route is selected from among alternative routes. When the minimum path is selected, waiting time or transfer time at bus stop is taken into account.
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.

7.3 Estimation of Future Zone Car Ownership

504. Since the zonal motorization is used as a variable in the car trip generation model, number of cars owned in future must be estimated. Car ownership has a close relationship with household income from analysis of the Vehicle OD 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 is used for the forecasting of zonal car owners, i.e., zonal motorization (cars/1000 persons) was estimated by inputting both future estimated income and population by zone. The figures are adjusted so that the total sum of future estimated cars of all zones was equivalent to the total number of cars estimated in Section 6.3.2 in Chapter 6.

505. The estimated car owners by zone are shown in Figure 7.3-1 which shows the comparison between figures in 1991 and 2010. The average motorization in the Study Area rises from 25 cars/1000 psn in 1991 to 56 in 2010, roughly a growth ratio of 2.2 times the present motorization. As seen, the motorization in zone Nos.1, 2 and 5 are higher. Those zones is forecasted to be 280 cars/1000 psn, 180 and 320 in 2010, respectively. Other zones are in range of 20 - 50.



Motorization 2010/1991

Figure 7.3-1 Estimated Motorization by Zone

7.4 Projection of Travel Demand

7.4.1 Total Number of Trips

506. The total number of trips per day in the Study Area in 2010 is approximately 2.76 millions, of which 2.64 million trips, equivalent to 96% to the total, are made by residents within the Study Area, and 124 thousand trips (4%) are for persons who are outside of the Study Area. The trip increase ratio of the year 2010 to 1991 is approximately 2.1, in contrast to 1.8 of the population growth ratio. Summary of trip flows in 1991 and 2010 is shown in Figure 7.4-1, and summary of socioeconomic and travel demand is shown in Table 7.4-1.

507. As for the trip composition of transportation mode, the share of car rises from 12% of the total trips in 1991 to 20% in 2010, while the bus share falls to 68% in 2010, in contrast to 82% in 1991. In conclusion, the future number of car trips sharply climbs by 3.6 times during two decades, corresponding to increase of number of cars (4.0 times). On the other hand, the bus trips rises to 1.7 times, relating to population growth of 1.8 times.

508. Table 7.4-2 shows the number of vehicle trips converted into passenger car unit (PCU). The modal share of car mode in pcu base is 30% in 1991, and the figure for 2010 is 6% higher (36%). On the other hand, bus mode is somewhat decreased from 32% in 1991 to 18% in 2010.

Table 7.4-1 Summary of Socioeconomic and Travel Demand

Items	1991 Figures	1991 Ratio	2010 Figures	2010 Ratio	2010/1991
1) Population	660,200		1,200,000		1.82
2) Population (5 years above)	598,800		1,108,800		1.85
3) No. of Vehicles	22,718	1.00	90,870	1.00	4.00
- Car	16,944	0.75	67,460	0.74	3.98
- Taxi	2,872	0.13	8,420	0.09	2.93
- Truck	2,902	0.13	14,990	0.16	5.17
4) Cars/1000 population	25.66		56.22		2.19
5) No. of Trips (all)*	1,259,400	1.00	2,639,358	1.00	2.10
No. of Trips * (Car+Taxi+Bus)	1,227,247		2,473,413		2.02
- Car	145,769	0.12	525,914	0.20	3.61
- Bus	1,028,998	0.82	1,786,883	0.68	1.74
- Taxi	52,480	0.04	160,616	0.06	3.06
- Truck	32,153	0.02	165,945	0.06	5.16
6) Trips /Population (5 Years above) (Car+Taxi+Bus)	2.05		2.23		1.09

Note: * Unit of trips is person base, not vehicle base.
The figures are only trips within the Study Area.

Table 7.4-2 Modal Share of Vehicle Trips (unit: pcu)

Type of Vehicle	Trips		Ratio		
	1991	2010	1991	2010	2010/1991
Car	78,791	284,382	0.306	0.357	3.61
Bus	83,590	145,157	0.324	0.182	1.74
Taxi	59,659	182,589	0.232	0.229	3.06
Truck	35,567	183,567	0.138	0.231	5.16
Total	257,608	795,695	1.000	1.000	3.09

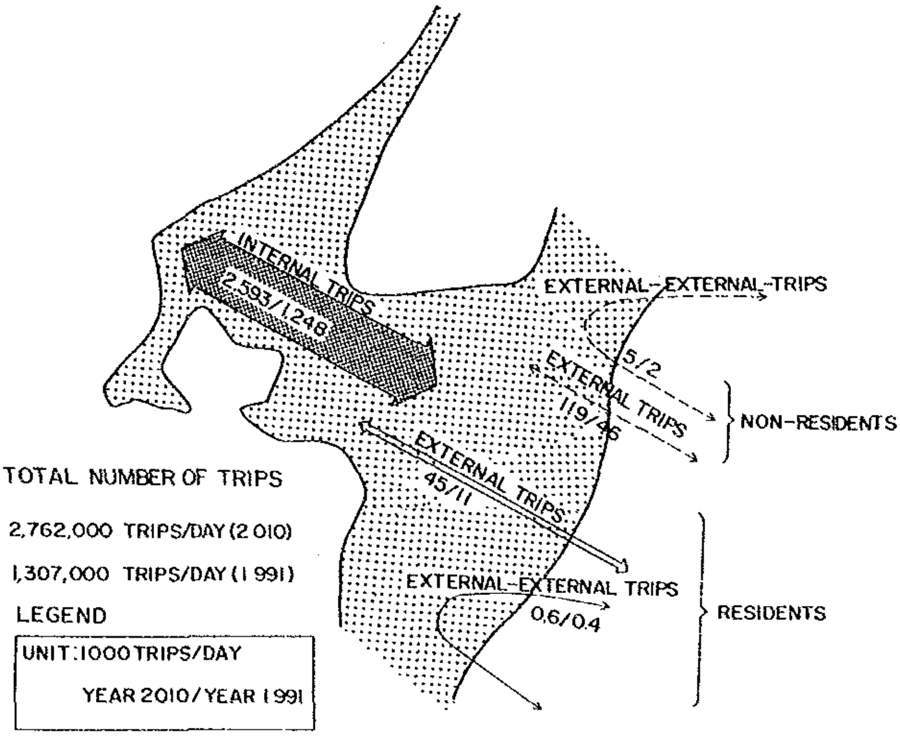


Figure 7.4-1 Summary of Trip Flow in 1991 and 2010

7.4.2 **Trip Generation and Attraction**

509. Estimated trip generation and attraction in the year 2010 according to the integrated zone are shown in Table 7.4-3, and Figures 7.4-2 and 7.4-3 show the composition of each mode by zone in 1991 and 2010, respectively. The detailed discussions are as follows;

1) Car

510. Table 7.4-3 and Figure 7.4-4 show comparison between the figures in 1991 and 2010. As seen, the trip generation and attraction in 2010 in zone Nos.1, 2, 4 and 5 are also heavy volume, maintaining the present trip pattern. The higher increase ratio of trip generation and attraction between 1991 and 2010 are in zone Nos.13, 18 and 15, i.e, the first two zones are in Mamonal industrial zones and the last is in the new development area.

2) Bus

511. Table 7.4-3 and Figure 7.4-5 show comparison between the figures in 1991 and 2010. As seen, the future trip generation and attraction in zone Nos. 2, 4, 10 and 11 maintain heavy volume, and those places will play the same important role in public transportation as at present.

512. The increase rate of trip generation and attraction during two decades in zone Nos. 13, 15, 16 and 18 becomes high (2.0 times or more), while residential area (zone Nos. 6-12) is somewhat low (1.1-1.5 times). This tendency is related to the population growth for trip generation and to the employment growth for trip attraction, respectively.

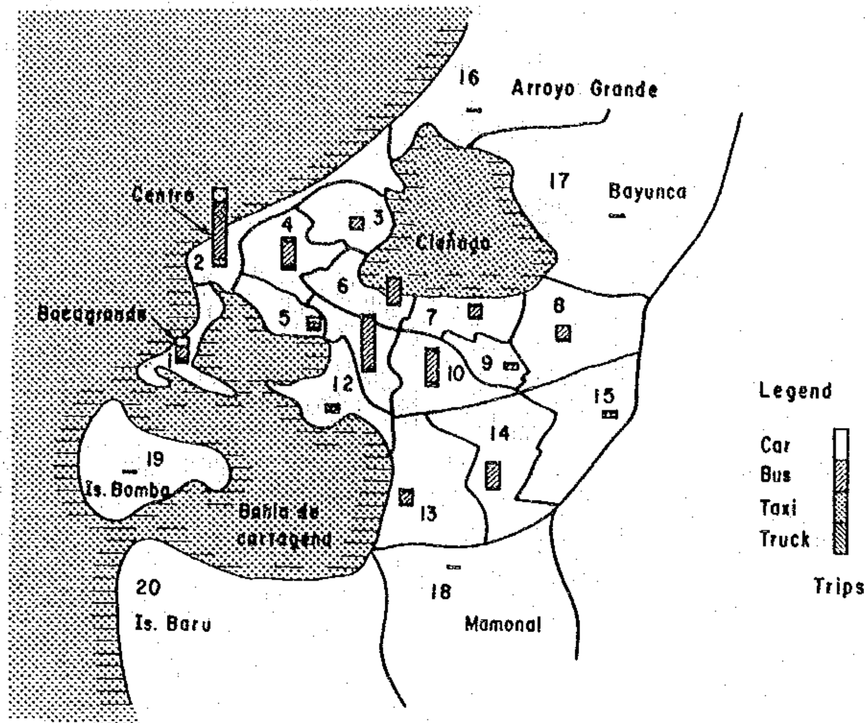
3) Taxi and Truck

513. The taxi trips show that the heavy trip generation and attraction are similar to that by car. As for the future trip generation and attraction by truck, the heavy volume concentrates on the zones (Nos.16 and 18) where large scale industrial projects are planned (refer to Table 7.4-3, Figures 7.4-2 and 7.4-3).

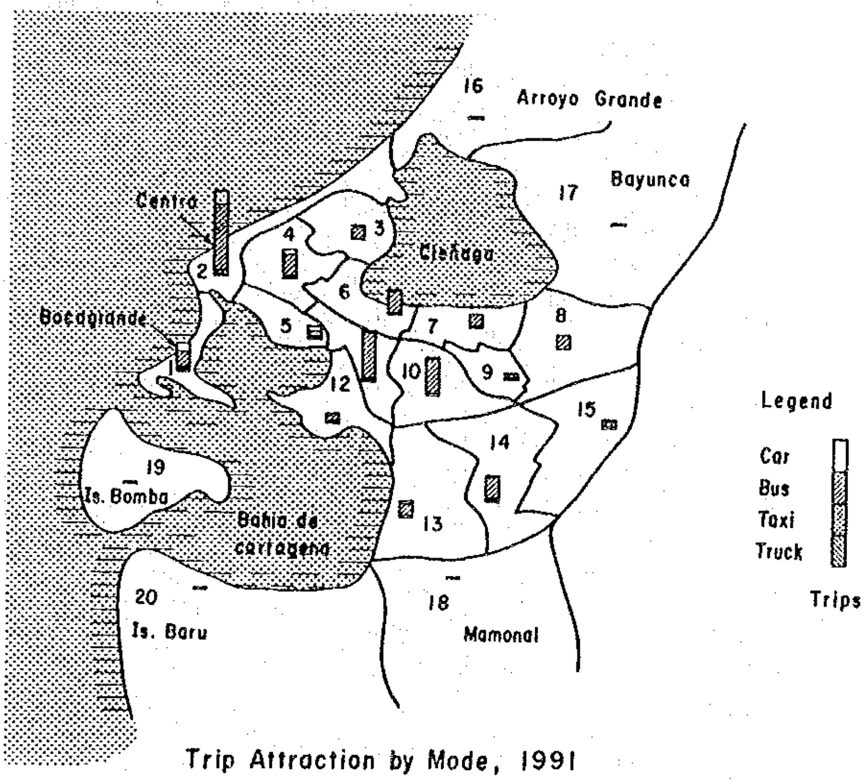
Table 7.4-3 Trip Generation and Attraction by Mode in 2010

Integrated Zone	Car (Person Base)				Bus (Person Base)			
	1991		2010		1991		2010	
	Gen	Att	Gen	Att	Gen	Att	Gen	Att
1	28,788	28,916	75,770	78,684	42,873	53,820	90,231	96,250
2	43,240	42,911	112,494	97,936	196,576	227,359	266,943	299,034
3	1,908	1,949	6,878	5,607	41,790	42,940	46,065	47,512
4	10,503	10,404	40,082	48,092	83,290	77,001	180,501	169,582
5	16,620	16,770	45,317	51,030	18,203	21,433	73,043	73,529
6	1,090	1,080	8,822	5,795	85,347	74,336	97,045	87,610
7	795	794	8,338	5,661	39,523	41,394	50,999	53,307
8	616	616	7,136	5,555	46,827	44,411	66,648	65,121
9	2,900	2,884	5,917	6,198	19,906	15,997	25,650	22,660
10	5,828	5,827	12,115	14,470	111,630	115,839	137,676	141,948
11	4,932	4,931	20,797	16,543	178,495	155,842	200,962	180,799
12	7,379	7,380	20,176	19,585	17,950	18,777	34,660	36,666
13	6,679	6,696	46,507	38,066	13,915	16,102	86,732	85,053
14	5,509	5,685	15,663	12,498	88,969	75,766	100,414	87,872
15	4,947	4,971	24,983	28,800	42,998	43,274	102,669	101,209
16	32	31	23,612	27,999	36	631	92,012	97,444
17	39	39	6,696	6,700	0	296	19,860	21,935
18	1,306	1,306	24,724	37,668	22	480	92,513	86,202
19	11	11	3,425	3,186	0	54	7,185	7,392
20	0	0	4,817	4,276	0	21	12,686	13,385
21	1,249	1,267	3,983	4,764	174	1,038	497	4,741
22	1,398	1,295	7,662	6,801	474	2,187	1,892	7,632
Total	145,769	145,763	525,914	525,914	1,028,998	1,028,998	1,786,883	1,786,883

Integrated Zone	Taxi (Person Base)				Truck (Person Base)			
	1991		2010		1991		2010	
	Gen	Att	Gen	Att	Gen	Att	Gen	Att
1	7,732	8,781	21,956	19,466	1,519	1,548	2,832	2,848
2	16,774	10,801	36,550	29,940	3,740	3,675	5,467	5,406
3	486	1,301	1,432	3,260	176	154	509	509
4	6,147	4,269	22,025	13,131	3,684	3,675	8,916	8,877
5	2,190	4,311	9,969	5,528	1,288	1,211	3,526	3,444
6	643	1,092	2,169	5,684	610	712	1,313	1,320
7	657	1,118	2,805	5,859	583	626	967	1,010
8	182	889	2,157	4,874	418	407	2,025	1,987
9	1,237	2,264	3,603	3,134	927	976	1,358	1,358
10	4,419	2,737	7,780	5,978	1,582	1,616	3,085	3,137
11	2,484	2,559	5,162	8,179	2,674	2,703	3,892	3,921
12	1,325	1,794	2,837	4,701	3,508	3,449	7,402	7,440
13	196	933	1,312	5,883	4,868	4,753	19,203	19,242
14	2,774	5,477	5,583	9,898	2,039	2,066	3,040	3,078
15	4,852	3,542	11,595	7,571	2,746	2,667	5,438	5,386
16	15	65	10,290	8,181	57	57	12,084	12,084
17	0	0	1,395	2,341	118	131	13,913	13,913
18	211	92	10,401	12,307	497	601	65,863	65,865
19	0	0	664	1,226	0	0	626	626
20	0	0	931	1,633	0	0	1,281	1,281
21	0	65	0	205	411	411	411	411
22	156	390	0	1,637	710	716	2,796	2,802
Total	52,480	52,480	160,616	160,616	32,153	32,153	165,945	165,945

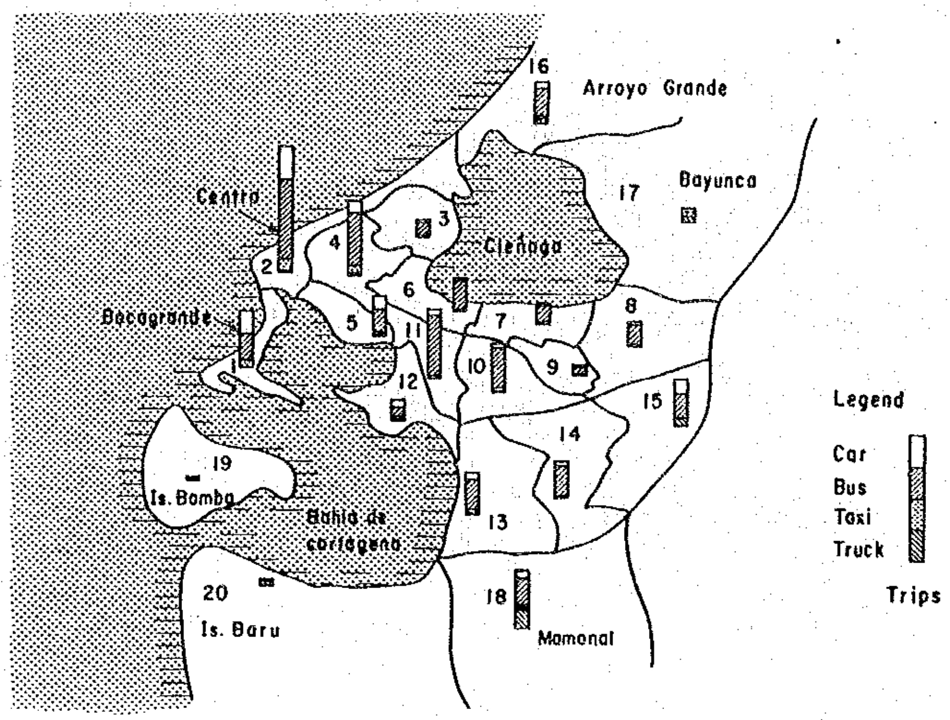


Trip Generation by Mode, 1991

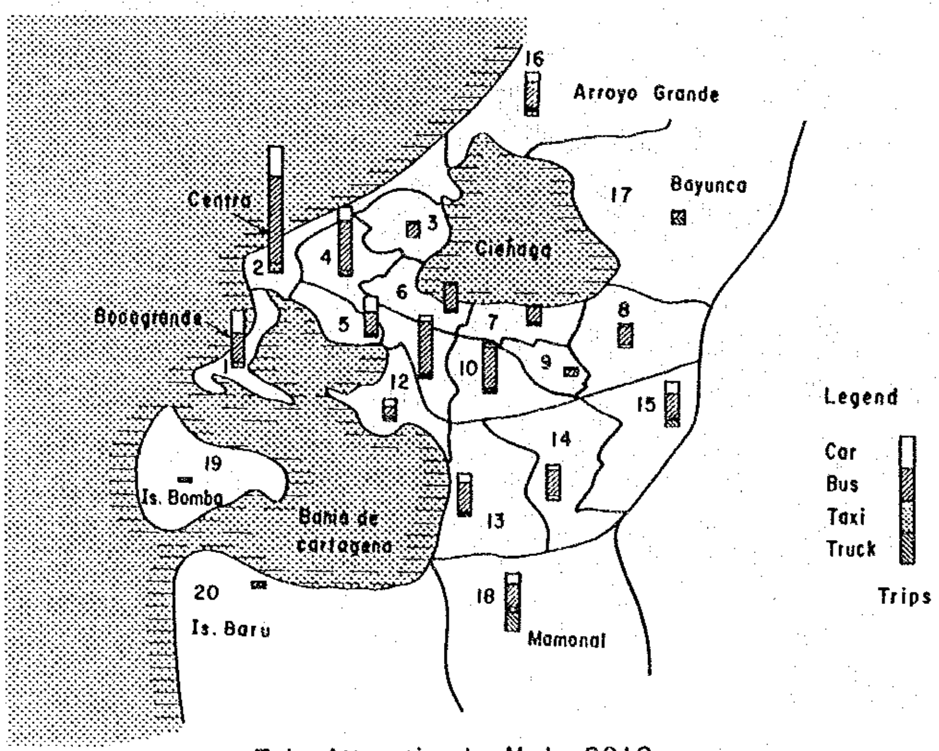


Trip Attraction by Mode, 1991

Figure 7.4-2 Composition of Each Mode by Zone in 1991

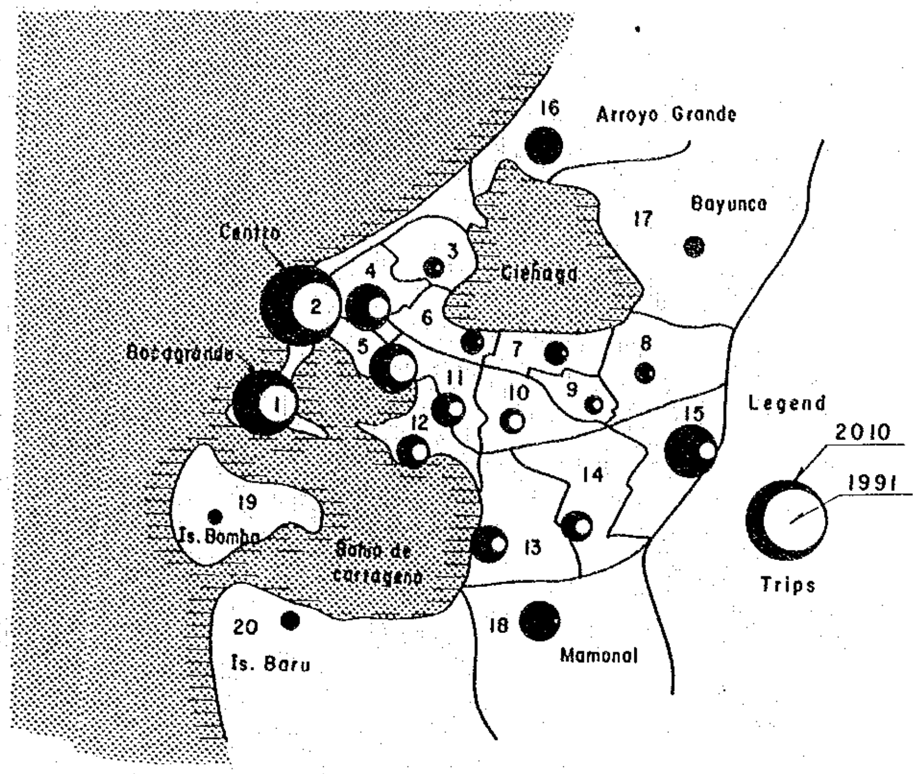


Trip Generation by Mode, 2010

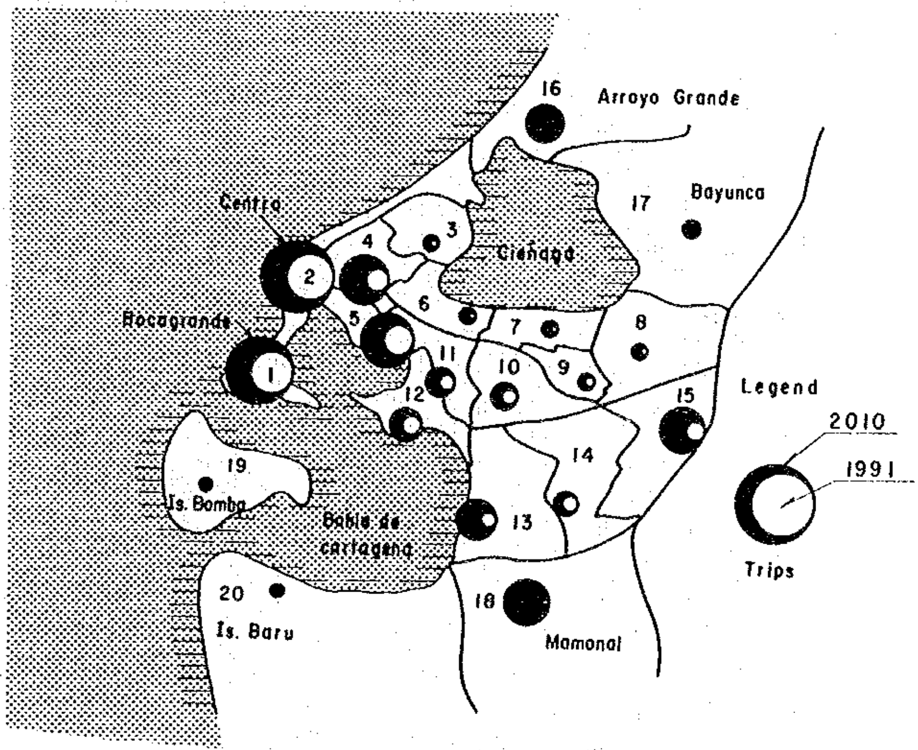


Trip Attraction by Mode, 2010

Figure 7.4-3 Composition of Each Mode by Zone in 2010

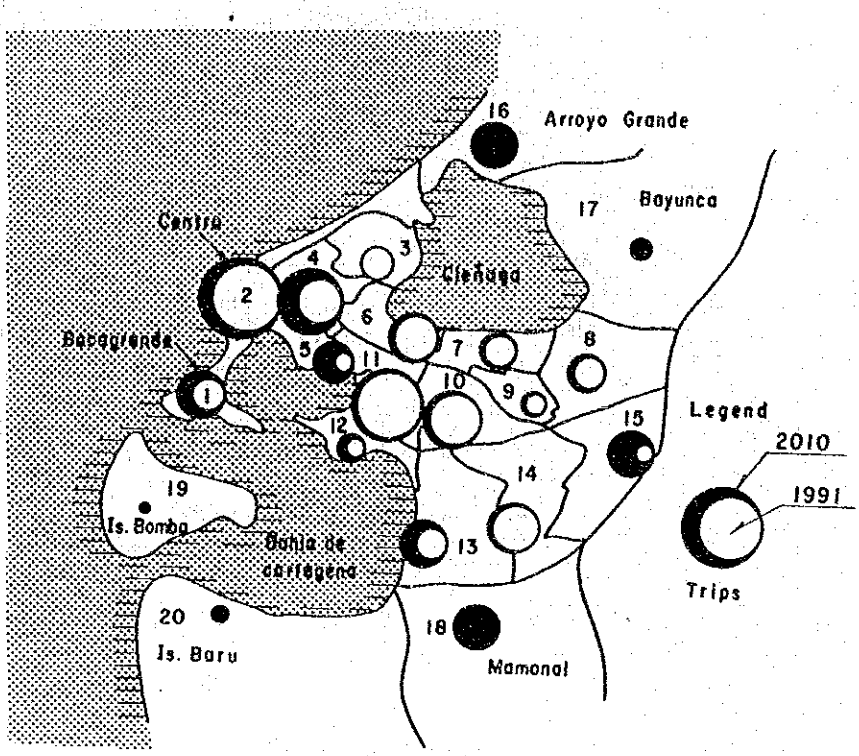


Car Trip Generation 2010/1991

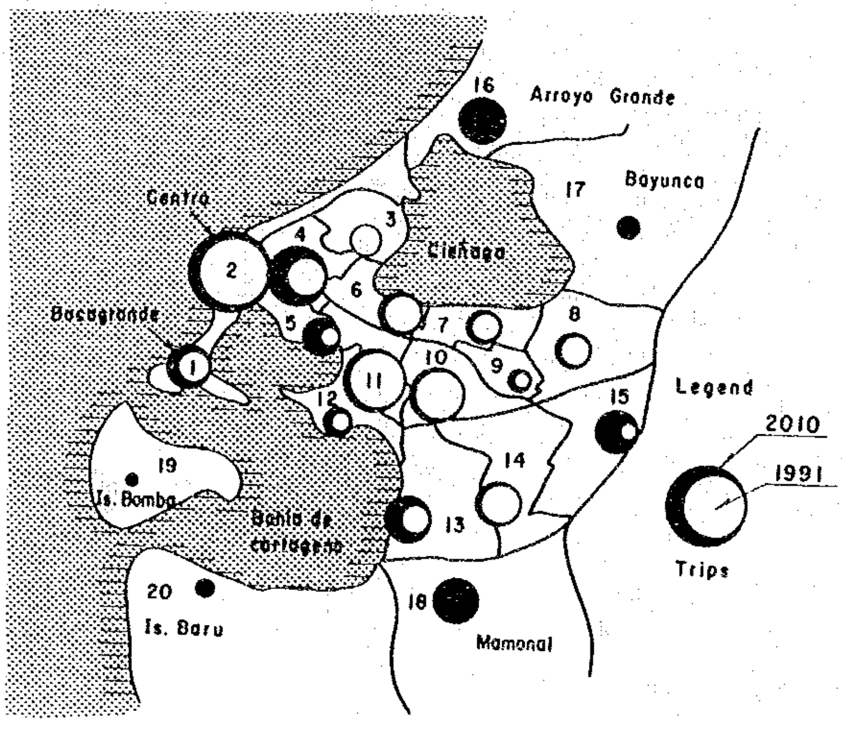


Car Trip Attraction 2010/1991

Figure 7.4-4 Comparison of Car Trip Generation and Attraction in 2010 with Those in 1991



Bus Trip Generation 2010/1991



Bus Trip Attraction 2010/1991

Figure 7.4-5 Comparison of Bus Trip Generation and Attraction in 2010 with Those in 1991

7.4.3 Trip Distribution

(1) Trip Distribution by Mode

514. The trip OD table for car in 2010 is shown in Table 7.4-4 which is integrated into 22 zones. Figure 7.4-6 illustrates the desire lines by car for interzonal trips in 1991 and 2010. As seen, car heavy trip flows in 2010 are between Centro (Zone No.2) and its surrounding area (zone Nos.1,4 and 5), and between Centro and the future developed area in sub-urban (zone Nos. 13, 16 and 18). The former shows the same trip movement as that at the present, and the latter shows those corresponding to the traffic to generate/attract from/to the future large scale developed areas. This shows that in future car trip movement will widely extend to the whole Study Area with heavy traffic.

515. The desire lines by public bus transportation are shown in Figure 7.4-7 which compares to traffic movements in 1991 and 2010. The trip OD table by bus in 2010 is shown in Table 7.4-5. The desire lines by bus also involve two trip patterns; one is the present trip pattern with more heavy traffic, and the other is new trip movements between Centro and sub-urban area (zone Nos.13, 16 and 18). In future, the strong desire lines by bus also widely extend to all the Study Area.

516. The taxi desire lines in future show that the heavy traffic movement still concentrates to Centro and its surrounding area (refer to Figure 7.4-8). As for truck, compared with strong desire lines in 1991 which is predominantly within the central area and between Mamonal, Bosque and others, OD trips in 2010 linked within Mamonal and between Mamonal and the northern parts of industrial area newly developed in the Study Area become considerably higher (refer to Figure 7.4-9).

Table 7.4-4 Car Trip OD Table by Integrated Zone in 2010
(Unit: Vehicle)

2010 Car OD Table/ Inside and Outside the Study Area (Vehicle Base)

Int. Zone	1	2	3	4	5	6	7	8	9	10	11	12
1	8,945	8,880	355	3,456	4,101	356	341	321	352	886	1,038	1,396
2	10,392	8,887	801	6,718	5,712	739	680	542	539	1,787	2,238	2,395
3	471	930	146	369	321	44	35	32	36	88	115	124
4	3,060	4,808	240	2,297	1,940	299	240	182	192	625	950	847
5	3,936	3,936	192	2,053	1,223	344	329	223	196	885	1,205	1,340
6	565	1,143	59	582	650	148	47	47	73	97	192	138
7	524	1,031	53	447	591	49	155	91	112	111	91	110
8	432	569	34	265	292	41	81	169	64	146	115	158
9	357	398	25	213	195	42	71	51	103	213	129	148
10	765	1,297	65	588	729	69	86	86	162	366	178	221
11	1,345	2,732	136	1,411	1,709	168	88	106	164	213	377	381
12	1,493	2,142	109	982	1,380	116	97	116	145	272	369	379
13	2,898	4,502	232	1,985	2,631	223	229	287	357	654	656	1,043
14	942	1,577	78	671	912	74	87	117	158	228	191	311
15	1,561	1,614	95	834	772	159	251	257	214	647	500	700
16	1,416	1,805	101	735	809	100	110	110	102	284	288	373
17	387	762	37	255	360	21	20	35	42	47	43	68
18	1,609	3,205	148	1,177	1,806	82	67	133	194	161	157	266
19	290	429	19	156	225	11	11	14	19	25	23	37
20	309	547	25	200	300	13	12	24	32	33	34	52
21	385	718	32	231	334	18	11	21	28	57	52	67
22	710	1,834	70	486	748	53	24	69	109	130	109	207
Total	42,792	53,746	3,052	26,111	27,740	3,169	3,072	3,033	3,393	7,955	9,050	10,761

2010 Car OD Table/ Inside and Outside the Study Area (Vehicle Base)

Int. Zone	13	14	15	16	17	18	19	20	21	22	Total
1	2,316	715	1,684	1,692	374	2,423	264	267	542	690	41,394
2	4,167	1,292	2,362	3,185	784	4,985	417	506	960	1,735	61,823
3	225	65	155	169	39	234	19	20	33	53	3,723
4	1,397	431	801	878	210	1,517	124	147	206	380	21,771
5	2,015	610	777	1,195	315	2,499	195	241	347	579	24,635
6	252	81	303	152	26	142	12	14	23	61	4,807
7	248	100	457	150	26	110	11	12	16	34	4,529
8	324	127	348	186	49	310	21	33	38	63	3,865
9	291	115	225	144	40	302	17	27	33	67	3,206
10	468	170	555	249	50	310	25	30	42	127	6,638
11	640	199	746	344	56	288	24	36	39	216	11,418
12	929	286	762	412	86	579	40	58	92	266	11,110
13	2,471	756	1,922	1,019	231	2,259	128	194	218	459	25,354
14	733	490	919	314	66	416	31	40	48	99	8,502
15	1,400	605	659	702	207	1,598	94	148	198	468	13,683
16	761	239	532	2,891	311	1,029	82	119	325	245	12,767
17	179	58	245	286	604	100	10	15	23	22	3,619
18	1,124	243	1,202	541	72	1,045	29	65	15	26	13,367
19	111	31	115	80	12	60	159	9	7	9	1,852
20	176	43	192	116	18	130	10	314	9	14	2,603
21	154	54	188	219	19	9	3	10	9	115	2,734
22	395	156	539	216	25	19	7	10	115	15	6,046
Total	20,776	6,866	15,688	15,140	3,620	20,364	1,722	2,315	3,338	5,743	289,446

Table 7.4-5 Bus Trip OD Table by Integrated Zone in 2010

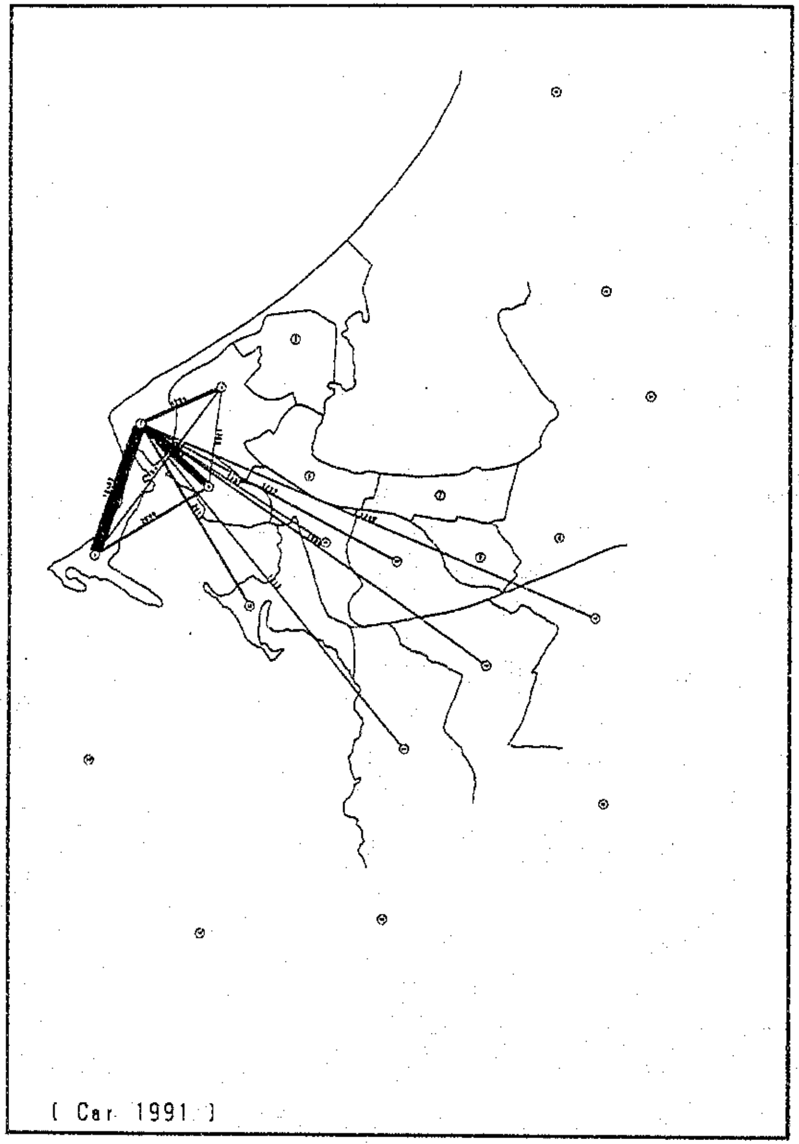
(Unit: Person)

2010 Bus OD Table/ Inside and Outside the Study Area (Person Base)

Int. Zone	1	2	3	4	5	6	7	8	9	10	11	12
1	13,049	20,774	581	7,932	4,480	2,332	1,336	1,202	961	7,207	3,663	1,384
2	22,626	31,329	17,563	22,296	12,393	15,460	11,295	11,666	2,988	26,943	28,614	3,803
3	732	17,835	10,767	9,793	770	159	522	234	212	613	830	775
4	10,236	29,600	10,999	17,763	9,680	8,523	5,105	5,181	1,786	13,006	13,947	4,219
5	4,277	12,937	905	9,170	3,278	1,714	1,212	1,391	617	2,624	6,408	1,707
6	2,835	19,335	175	8,717	1,113	13,236	2,808	4,213	1,504	9,003	20,106	945
7	1,489	11,047	474	5,529	990	2,157	4,382	7,675	420	2,272	6,540	525
8	1,329	16,996	380	6,893	1,453	3,702	5,969	6,544	1,021	1,903	8,573	732
9	1,340	6,081	579	2,275	473	1,236	645	1,369	1,474	1,631	1,849	403
10	5,754	29,784	734	11,557	3,488	6,973	2,780	4,079	2,400	20,977	14,921	1,991
11	3,656	34,946	873	15,520	5,322	19,444	8,048	8,889	1,868	23,546	38,399	7,707
12	974	4,750	317	4,086	2,064	1,227	342	502	234	1,496	7,664	1,183
13	3,130	9,618	479	10,744	5,076	1,455	975	2,205	667	4,308	6,230	3,561
14	4,334	19,738	720	5,115	4,965	3,629	2,253	487	2,060	13,275	11,390	1,238
15	4,676	13,374	776	8,628	4,087	3,253	2,767	4,023	2,866	6,579	5,764	1,984
16	7,105	6,824	454	7,820	5,422	1,297	1,280	1,979	629	2,513	2,234	1,939
17	773	1,892	93	1,963	1,035	226	213	465	124	506	422	294
18	6,726	9,915	490	11,392	6,177	1,330	1,159	2,533	701	2,988	2,607	1,799
19	389	757	35	882	463	93	76	158	44	192	174	113
20	509	1,058	53	1,209	677	145	131	273	77	322	280	203
21	631	4,105	136	694	340	115	326	140	273	575	2,828	635
22	1,291	13,985	404	2,237	958	100	654	43	1,116	1,904	5,455	1,715
Total	97,861	316,680	47,987	172,215	74,704	87,806	54,278	65,251	24,042	144,383	188,898	38,855

2010 Bus OD Table/ Inside and Outside the Study Area (Person Base)

Int. Zone	13	14	15	16	17	18	19	20	21	22	Total
1	3,956	2,493	5,058	5,570	1,105	5,125	513	664	516	1,898	91,799
2	8,539	12,967	11,385	11,016	1,926	11,082	670	1,002	2,468	16,991	285,022
3	350	574	700	461	88	487	33	48	45	164	46,192
4	10,435	5,054	8,089	9,917	2,212	11,092	891	1,288	1,862	2,403	183,288
5	5,449	1,523	3,985	6,045	1,257	6,455	543	779	575	2,179	75,030
6	1,167	4,274	4,891	1,177	214	975	79	129	260	424	97,580
7	747	1,548	2,586	1,219	213	821	68	125	396	710	51,933
8	1,849	605	3,243	2,180	467	2,086	142	264	245	377	66,953
9	622	1,378	2,765	556	121	575	40	71	335	629	26,447
10	4,868	13,365	7,013	2,660	570	2,741	222	349	524	1,761	139,511
11	7,927	12,220	6,926	2,138	443	2,036	151	256	5,351	5,725	211,391
12	2,411	1,319	1,843	1,749	313	1,483	113	203	490	1,681	36,444
13	8,904	1,696	7,475	7,718	1,603	8,617	561	1,049	324	2,076	88,471
14	1,475	18,681	7,328	1,211	248	1,303	83	154	689	1,223	101,599
15	7,207	7,005	11,002	6,425	1,579	8,135	521	929	1,256	2,881	105,717
16	7,501	1,130	5,306	24,052	3,911	6,413	886	1,465	949	910	92,019
17	1,238	244	1,413	3,627	2,751	1,941	149	275	101	118	19,863
18	8,919	1,513	8,558	7,100	2,419	11,742	922	2,543	350	637	92,520
19	495	91	522	885	161	794	657	141	25	39	7,186
20	922	162	886	1,436	290	2,165	137	1,623	47	82	12,687
21	80	1,044	476	79	10	20	23	4	430	467	13,431
22	1,151	1,295	2,358	224	34	112	10	22	899	487	36,454
Total	86,212	90,181	103,808	97,445	21,935	86,200	7,414	13,383	18,137	43,862	1,881,537



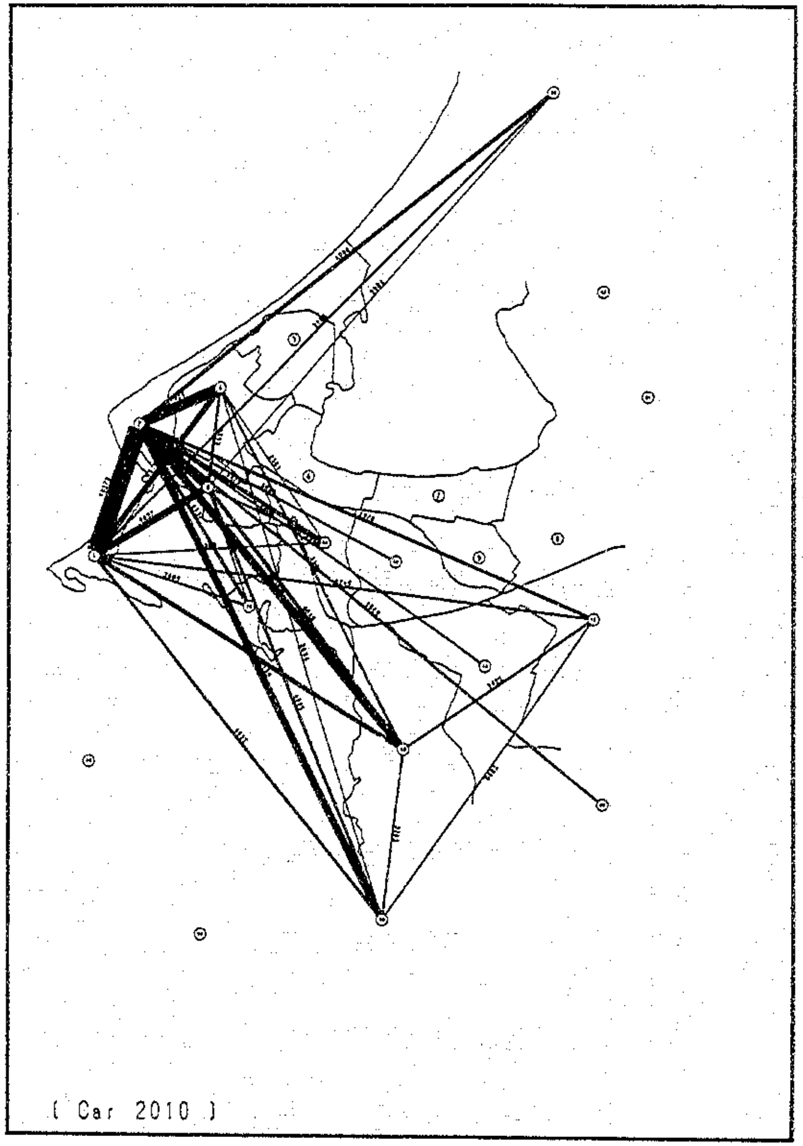
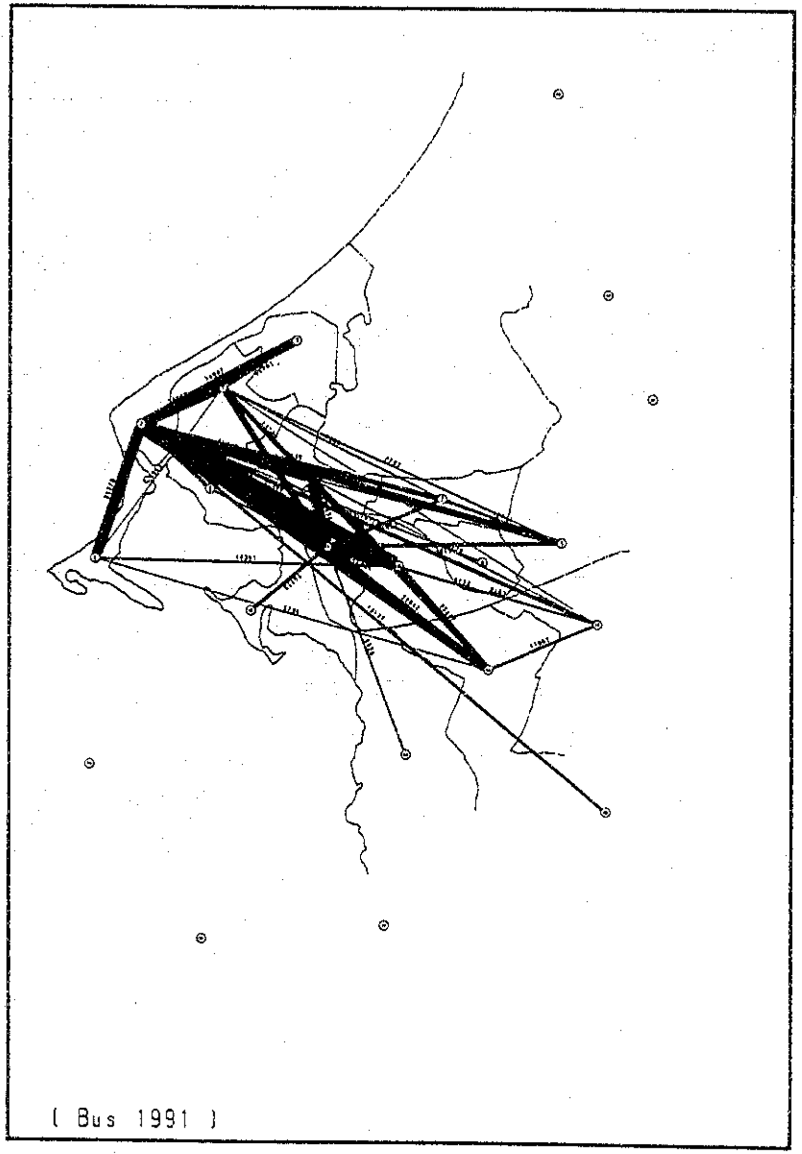


Figure 7.4-6 Car Trip Desire Lines in 1991 and 2010



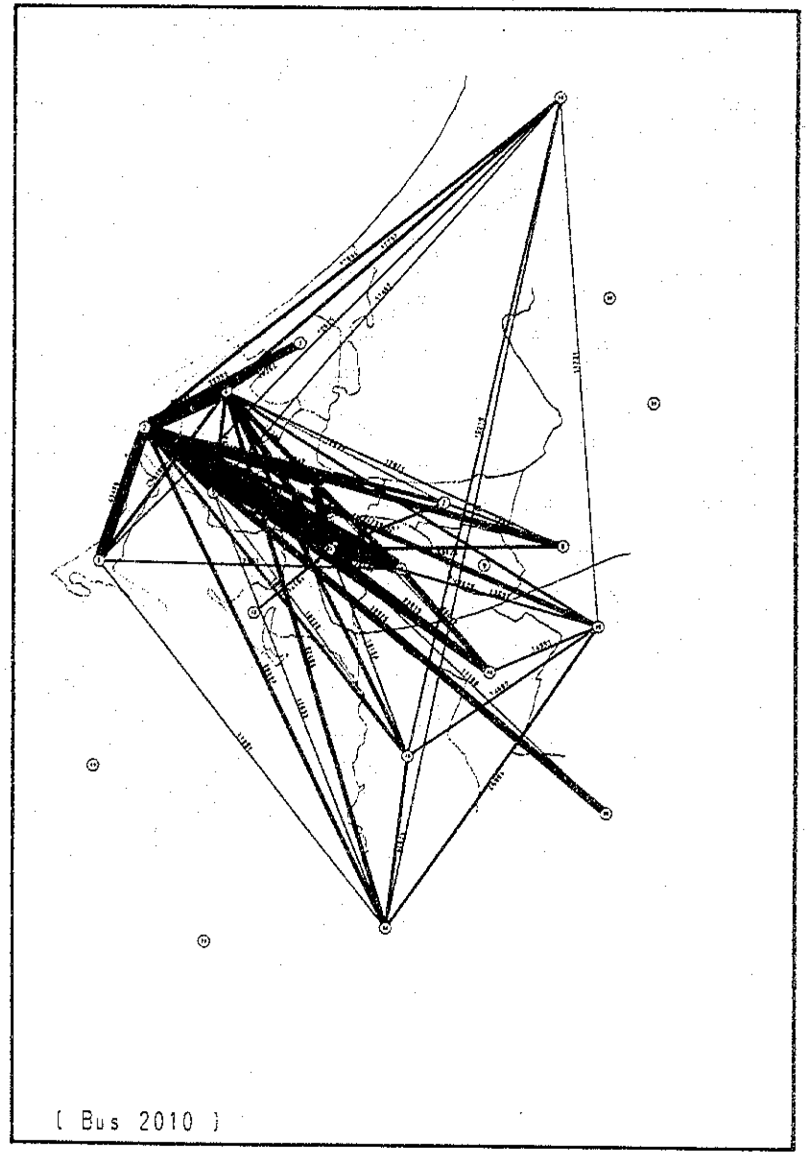


Figure 7.4-7 Bus Trip Desire Lines in 1991 and 2010

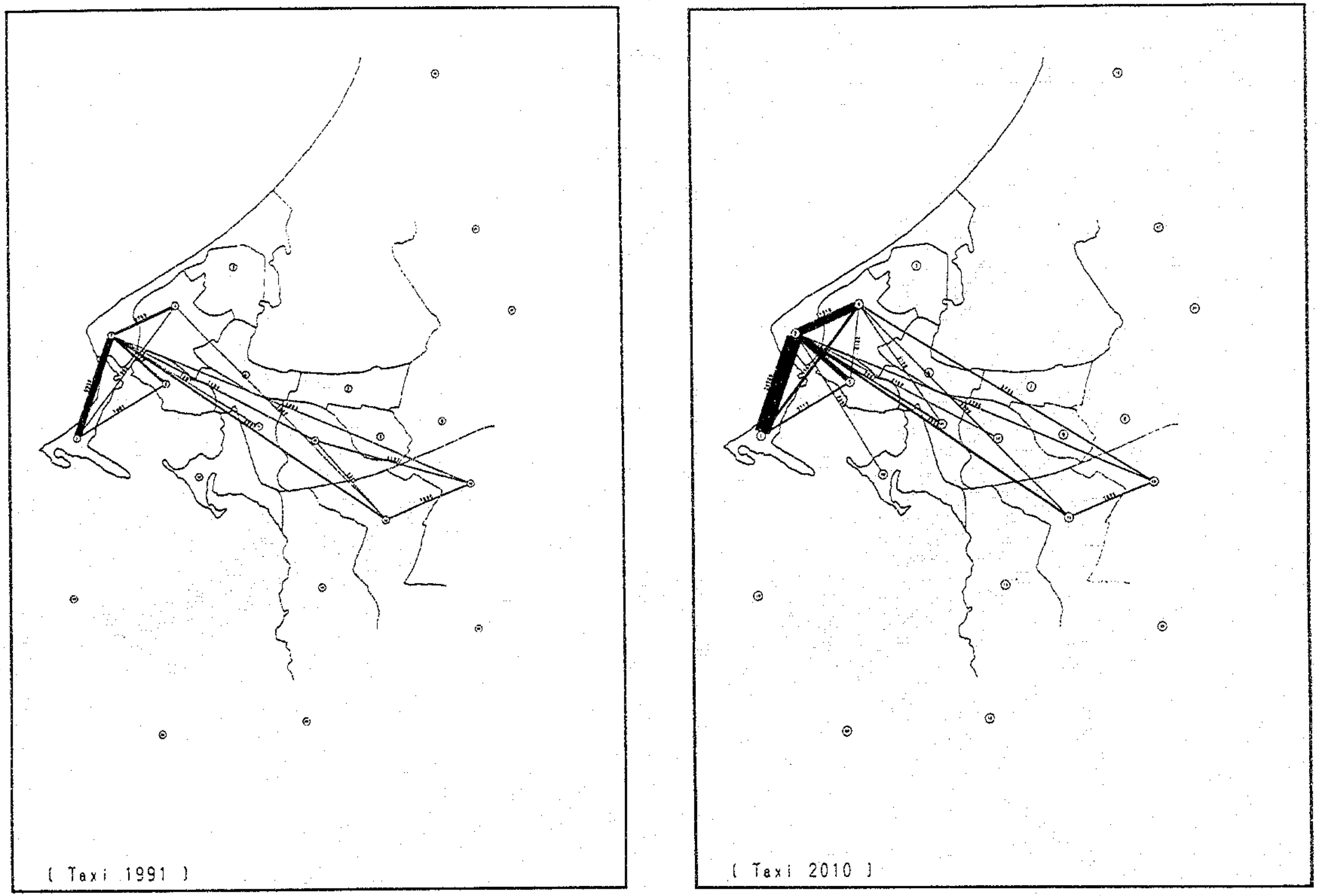


Figure 7.4-8 Taxi Trip Desire Lines in 1991 and 2010

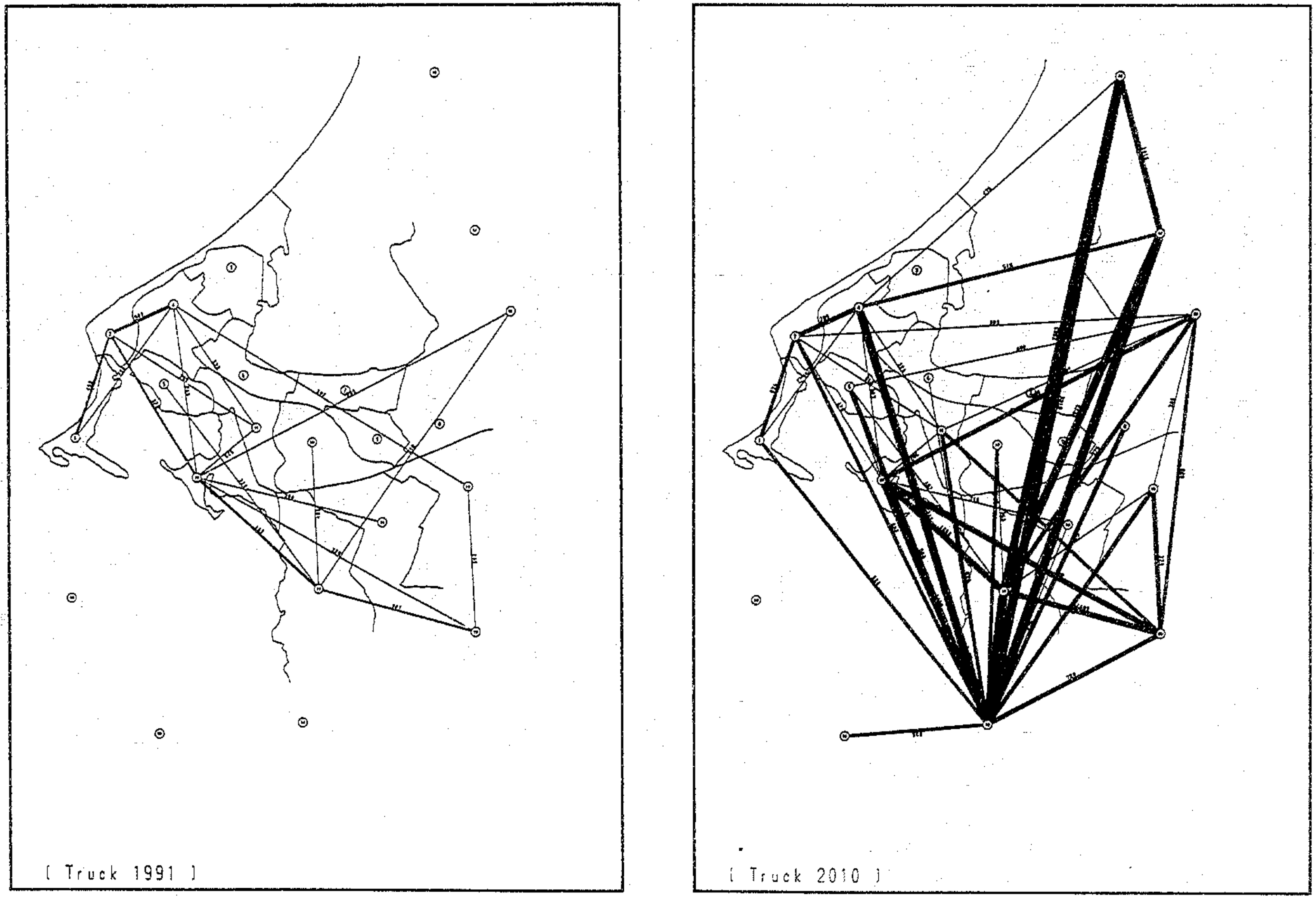


Figure 7.4-9 Truck Trip Desire Lines in 1991 and 2010

(2) Trip Length Distribution

517. According to expansion of urban area in future land use planning, trip length increases in future. The trip length distribution by mode in 1991 and 2010 is compared in Figure 7.4-10 which shows by car, bus and truck. The average trip length by car in 2010 is 12.4 km, in contrast to 7.4 km in 1991. On the other hand, the bus passengers will travel shorter distance than that by car. The figure in 1991 is 6.1 km and increases to 10.8 km in 2010. The average trip length by truck is the longest among all modes. In 1991 it is 13.1 km and in 2010 becomes longer, 23.0 km.

518. Approximately 85% of the total trips by car in 1991 have trip length within 10 km. In 2010 this figure is expected to be 26 km, an increase of roughly 16 km. As for bus, the accumulative percentage in 1991 reaches to 85%, 8 km and in 2010 the figure extends to a distance of 24 km.

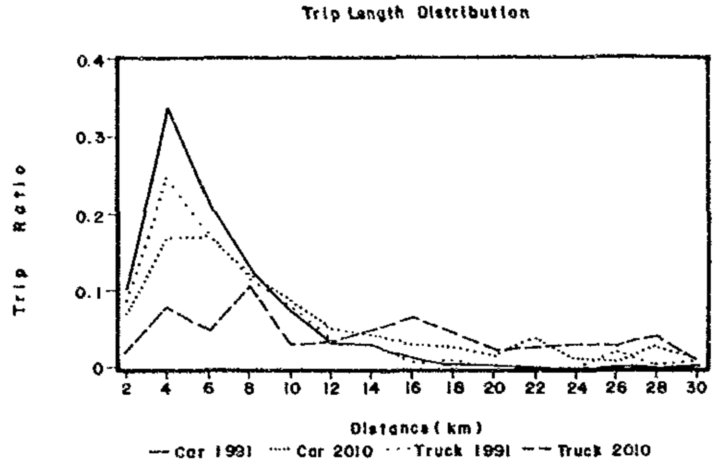


Figure 7.4-10(A) Trip Length Distribution by Car and Truck

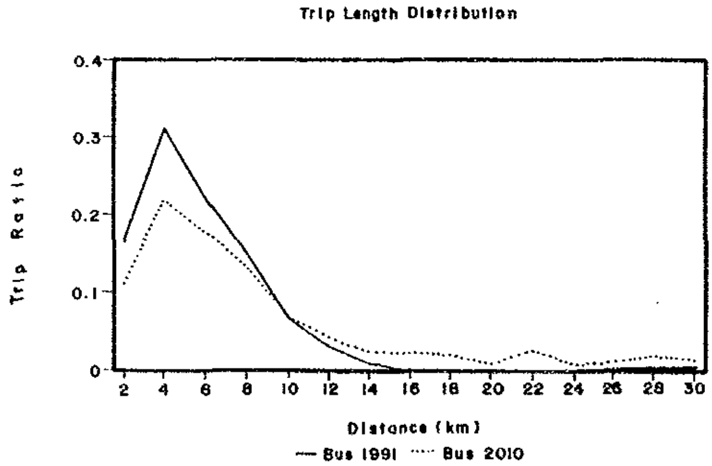


Figure 7.4-10(B) Trip Length Distribution by Bus

7.5 Traffic Demand on Present Network

519. Traffic assignment is made under the conditions on which the OD trips in 2010 loads on the present network to disclose traffic demand on major corridors. The traffic demands in 1991 and 2010 are shown in Figure 7.4-11 and 7.4-12, respectively. In those figures, the traffic volume on each road is drawn by a narrow band whose width is proportional to the assigned traffic volume. Comparing to traffic volume in the both figures, the traffic volume-capacity ratio in 2010 is more than 1.5 on almost all the roads as represented with black line in the figures, while at the present no roads exceed 1.5. The future traffic conditions will be severe, if no improvement will be made for the transport network.

Figure 7.4-11 Traffic Demand in 1991 on the Present Network

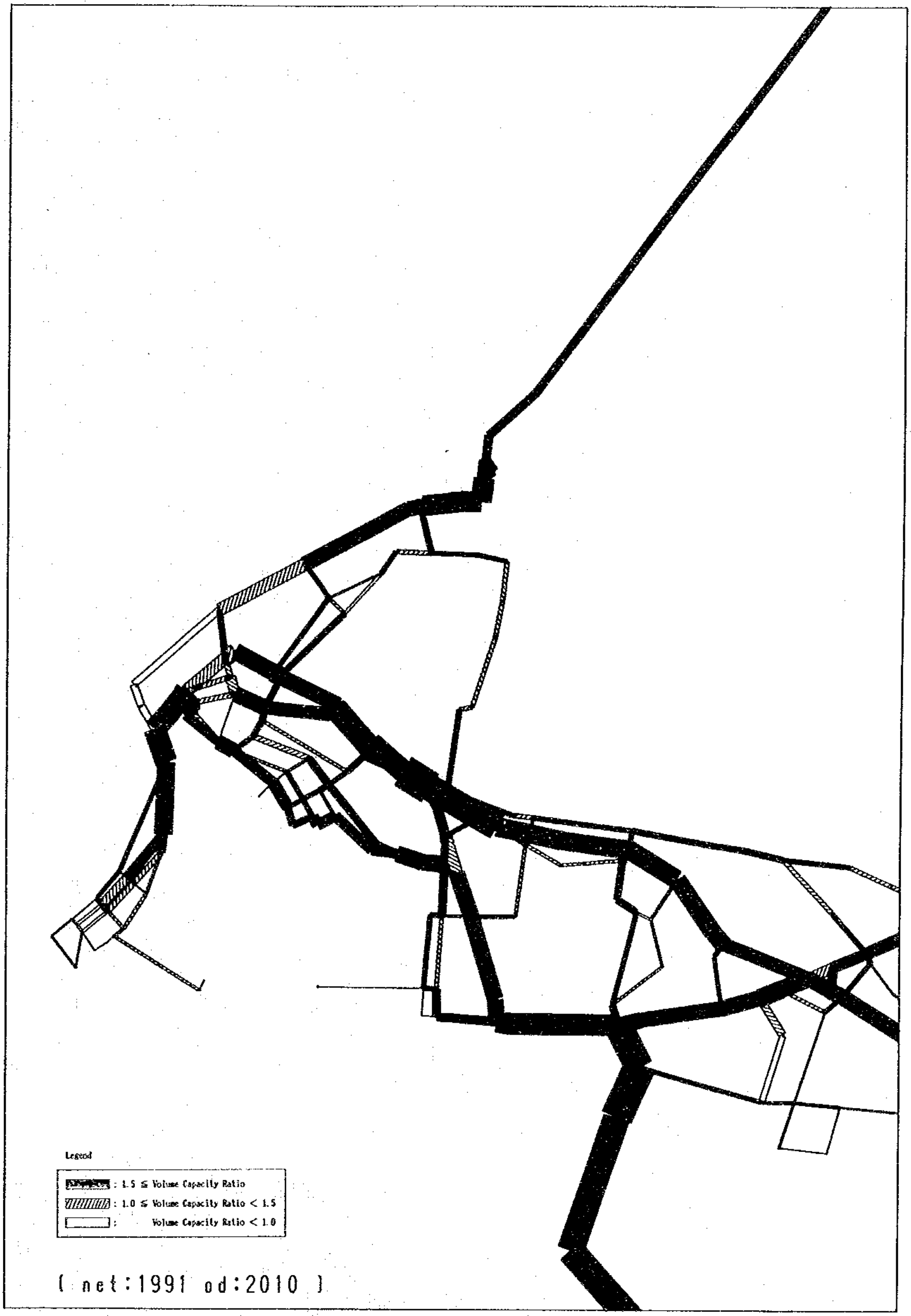


Figure 7.4-12 Traffic Demand in 2010 on the Present Network

CHAPTER 8 URBAN TRANSPORT PLANNING POLICIES

8.1 General

520. Urban transportation network is to be formulated in order to serve efficiently the transport and traffic demands at present as well as in future. It shall be constructed taking into consideration the geological, topographical, historical, environmental and also socioeconomic conditions of the Area.

521. Cartagena has such characteristics as port, industrial and tourism city. To support the activities of these city functions in future, the improvement of transport infrastructure is the basic requirement. In addition to these requirement, the improvement of commuting system for the residents in the Study Area is also very important.

522. Due to the historical development of Cartagena, the central business district (CBD) locates at the western edge of the Study Area and the existing urban area stretches in the directions of north, east and south from CBD. The concentration of traffic and public transport into CBD in Cartagena is the same as in other cities in the world.

523. Road network system can not easily follow the urban area expansion resulting from the recent rapid population growth in these decades. The primary road network is not established and also the secondary class roads for the motor vehicles are very poor condition in the residential areas.

524. Public transportation is owed mainly to bus transportation, which shares some 80 % of the total person trip in the Area. Due to the low car ownership (26 cars per thousand inhabitants in 1991), traffic volume on major arterial roads is at acceptable level. Comfortable public transportation system is expected to promote social equity as well as to maintain a lower car ownership.

525. Car ownership in the Study Area increased at a rate of 13 % per annum for last decade in the Study Area. However, the ratio of car-owned households is only 10 % in 1991 and still at lower level compared with Barranquilla (16 % in 1982). This rate is forecasted to be still at high level in near future, however, it will become to be moderate because of the household income distribution of lower level mass and very high car prices. Taking into consideration the population growth of 1.8 times and car owned households ratio increase of 2 times by 2010, more than 4 times as many private cars will make trips in the Study Area.

526. This traffic and transport situation will be relieved by the traffic and transport system improvements. However, the basic cause for the traffic/transport concentration into the CBD will be solved by the improvement of the current land use. The changes of land use pattern will save some parts of investments required for the traffic/transport improvements.

527. The growing population of the Study Area introduces the expansion of the urbanized area and heavier loads on current traffic/transport network. Poor traffic/transport network system will bring the spatial segregation by income level (farther residence zones from CBD for lower income people).

528. The development of the Mamonal industrial area and future port area require the effective freight transport corridors connecting with the outsides of the Study Area as well as the convenient commuting system of the people in the Area.

529. Furthermore, the tourism promotion requires the improvement of the transport system in the Central area, where the major tourism spots now concentrate, and also the establishment of the transport system in the northern area of the Study Area where future tourism development is expected.

530. In order to accept the future population increase and to support industrial growth in the Area, the spatial development in the northern and southern parts of the Study Area is to be avoided. Several functions or the parts of which are now concentrated in current CBD will be moved.

531. The future land use is effective when supported by the necessary and sufficient social infrastructures. Spatial expansion in the following decades will be quite larger than current urban area because almost all good land for the development in existing urbanized area is already occupied and the topography being surrounded by water surfaces. Therefore, the establishment of the transportation network system will be primary component for the new developed territories.

532. In the Study Area, only land transport is available. From view points of the usage of the available resources and the savings of the investment for the land transport, introduction of the other transport mode such as water transport is to be considered taking into consideration the topographic condition of the Area.

533. The following are the basic objectives for planning the urban transport network in Cartagena taking into consideration the existing and future socioeconomic and traffic/transport situation;

a. to satisfy the social equity in transportation,
b. to support the regional development of industries and housing, and
c. to create and maintain a high quality of urban environment.

534. These objectives are translated into following targets;

a. satisfaction of transport needs at present and in future,
b. effective use of existing facilities,
c. compatibility with future urban structure and land use plan,
d. equal access to transport services for the residents,
e. improvement of traffic safety,
f. saving of social transport cost, and
g. minimization of adverse effects on the environment.

8.2 Road Network System

8.2.1 Concept of Road Network System

535. In order to integrate the Study Area in future, the trunk and arterial road network shown in Figure 8.2-1 will be required. This is the global concept of the road network in future not limited until 2010. Its construction stage will be examined in the following Chapter. These are;

Trunk roads; -Av. Pedro Heredia and
-National Roads to Medellin and Barranquilla
Arterials ; -Bayunca Rd. and its extension to north from Crespo to Cienaga de la Peña,
-Trans-Baru Island Rd. from Pasacaballo to Baru,
-Cartagena Bay Rd. from Castillogrande to Bosque through Tierra Bomba, Pasacaballo and Mamonal,
-Outer Ring Rd. from Tierra Bomba to Boquilla,
-Coastal Rd. from Bocagrande to Crespo,
-Inner Ring Rd. around Manga, Bocagrande and Bosque
-Diagonal 22 and Carretera Troncal.

536. Geometrical standard for these roads shall be decided based on the volume of traffic demand as well as minimum requirement of the function.

537. For the urban area, the arterial and collector road network shown in Figure 8.2-2 will be necessary to be improved to satisfy the growing transport demand of the area. In addition to this, the local road network available for motor vehicles shall be established especially in the residential area.

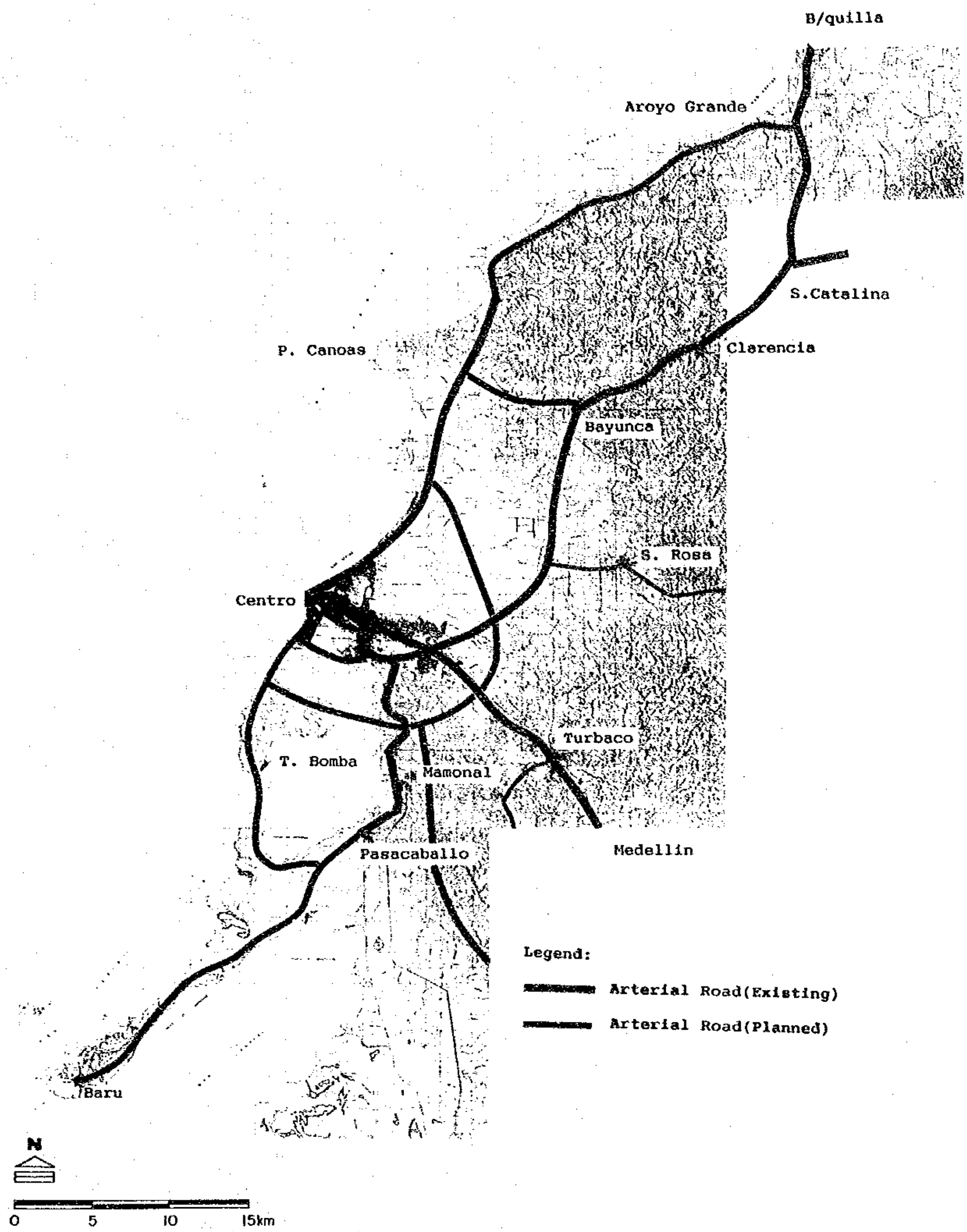


Figure 8.2-1 Future Road Network

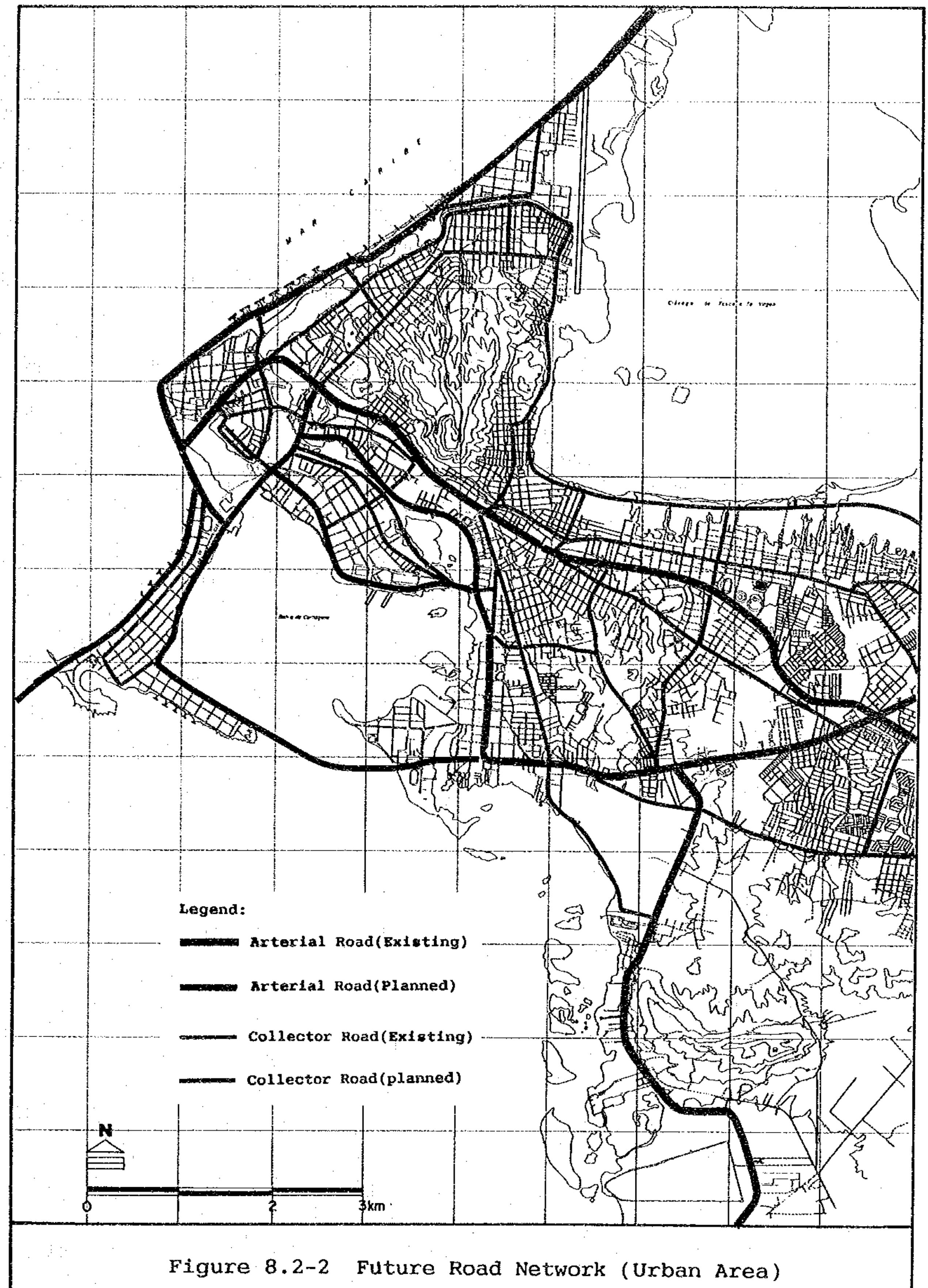


Figure 8.2-2 Future Road Network (Urban Area)

8.3 Public Transportation System

538. The modal share between public and private transportation is forecasted not to dramatically change in the Study Area because of the slow income structure change and high car price level compared with average income level. At present more than 80 % of the person trips depend on public transport, mainly on public bus transport. It is forecasted to be about 70-75 % in 2010. To provide people the comfortable public transport means is a basic public service which the Municipality has to arrange. It will also be useful to lessen the increase of the private car ownership.

539. Considering the population size and financial difficulties for introducing the railway system (metro/light rail transit system), improvement and expansion of the current public bus transport system is considered to be the most realistic solution in the Study Area. The water transport is considered as supplemental system to bus transport for the specific areas along the canals, bays and lakes. However, the existence of this different mode transport system is to reduce the demand for the public bus transport and therefore to lessen the load to invest the road network in future. This system seems to be also attractive for the tourists when the routes' areas are developed as tourist zone.

540. In regard to public transportation, the following aspects of the services shall be examined;

a. network density,
b. number of operation,
c. punctuality,
d. safety,
e. convenience/comfort, and
f. economy

541. Considering the above view points and existing issues on public bus service, the following basic polices for the improvement of public bus transportation are used;

1) in short term

a. public bus facilities improvement

- construction of bus stop and bus terminal

In the designated road sections, stops outside bus-stop are restricted. And parking is allowed at bus terminals or parking spaces only. Especially in the Central area, bus terminal is required for passenger service improvement as well as traffic flow improvement.

b. public bus operation improvement

- renewal of old bus vehicle

  Through the vehicle licensing by DATT, accelerate the renewal of old bus vehicle (for example 20 years for bus and 15 years for buseta).

- designation of public bus arterial routes

  By designation of bus arterial routes, prepare and introduce public bus priority and/or exclusive lanes.

2) in medium/long term

a. bus operation system improvement

- introduction of trunk-feeder system

  On public bus arterial routes, introduce trunk bus operation system. Feeder bus system is arranged to serve for the local areas to be connected with terminals on trunk bus route.

- construction of public bus trunk/feeder terminal

  On both ends of the trunk routes and major nodes on the routes, public bus passenger terminals are constructed for the transfer of the passenger from/to feeder bus routes.

542. In regard to the water transport, operation possibility on several routes are examined from socioeconomic as well as financial view points. In order to confirm the inter-relationship with bus network, several transfer points are prepared for the passenger convenience.

8.4 Traffic Management

543. Traffic management includes many aspects of activities such as planning, design, enforcement, education, etc. for the traffic regulation, traffic sign and signal, parking, traffic flow movement, traffic safety and so on. These aspects have comprehensive relationship to each other for an accomplishment of the smooth traffic flow which is the final object of the traffic management. However, in this Masterplan, physical matters of these aspects are mainly taken into consideration due to the difficulty and complication of other factors to be included in the Plan.

544. The basic policies for traffic management system improvement are;

a. simplification of the system,
b. rationalization of the system, and
c. clarification of the system.

545. Taking into consideration the improvement progress of the road network and public bus transportation, the following objectives are examined from above view points;

a. classification of road network by function,
b. reassignment of one-way system,
c. assignment of public traffic arteries,
d. reevaluation of parking and stop regulation,
e. intersection improvement including signal installation, and
f. signal coordination.

8.5 Environmental Consideration

546. In planning the road network system as well as water transport system, it is foreseen for the construction of those systems to give some environmental impacts to the areas developed. Especially in the Study Area, water side development shall be carefully examined from view point of natural resources protection. Inland area of the Study Area is already urbanized or developed for agriculture and seems not to have any specific precious natural resources.

547. Based on the recommendation on environment assessment by Organization of Economic Cooperation and Development (OECD) in 1985, it is requested to carry out the environment assessment at early stage of project or program in case of the possibility to give a severe influence on environment of the place developed.

548. In the Study Area, mangrove forest in Baru Island and historical monuments in Central area are the major questions to be considered for the Master Plan. It is requested in the Development Master Plan of the Municipality to pay serious attentions for protection of these resources.

549. There are several limitations to carry out the detailed environmental assessment for the planned projects in this Study. However, it is possible to point out the areas and necessities for the environmental assessment for the project implementation.

550. The following items which seem to have potential environmental impacts on the planned projects shall be checked;

a. kind and degree of impact,
b. avoidable or not by alternative plan, and
c. necessity for detailed environmental study.

CHAPTER 9 ROAD NETWORK PLAN

9.1 General

551. By the year 2010 the population in the Study Area will have grown to about 1.2 million (1.8 times of the present) and the number of trips generated in this area will be expected to be approximately 2.64 million trips (2.1 times). As a result, due to the increasing traffic volume, the future urban activities will be getting worse if no improvement for road transportation facilities will be made. Therefore, it is indispensable to make a future road masterplan as mitigation measures for these problems. In this Study, the road masterplan was prepared for the target year of 2010.

552. First of all, in the planning procedures, a long term plan was prepared to achieve the ideal road network to meet future land use plans, regardless as to whether road implementation is completed or not by the target year. The long term plan was made by reviewing the existing road network plan: "Plan De Desarrollo De Cartagena in 1987-2010" made in 1987 by the municipality of Cartagena, and by including the committed projects by EDURBE and Departamento Administrativo de Valorizacion Distrital.

553. In the second step, the road masterplan for the target year of 2010 was prepared incorporating those projects in the long term plan according to the results of the traffic assignment and economic evaluation. In order to select the most effective plan as "the road masterplan", five (5) alternatives of the road masterplan in 2010 were also made from the long term plan. From those alternatives, the road masterplan in 2010 was selected taking into consideration of traffic and economic aspects.

554. Finally, implementation schedule was made in order of higher priority projects in the road masterplan under the economic viability. The high priority projects were taken based on traffic aspect, network configuration, urban development and cost performances from economic stand point.

(1) Traffic Demand in Future

555. In 1991 the desire lines show that traffic movement in the Study Area is primarily by cars concentrating to Centro from its neighbor zones and by bus to Centro from every residential area. The traffic movement is found to concentrate into the corridor through the narrow belt near Mercado (Public Market) from the whole urban area, consisting of Av. Pedro de Heredia and some roads in Manga. Approximately 40% of the total trips in the passenger unit pass through the Screen Line located near Mercado. On the other hand, traffic volume in the Study Area exclusive of that corridor from Boca Grande to Mercado (Public Market) is considerably less.

556. Table 9.1-1 shows traffic volume and the volume-capacity ratio on the imaginary sections (refer to Figure 3.3-10), which compare the present conditions with the Do-Nothing case of 2010 year's OD trips assigned on the present network. At the present, there are no saturated sections on the roads in the Study Area, exclusive of the section No.7: Boundary of the urban area, in terms of the traffic volume-capacity ratio. These situations will continue for only a few years if no improvement of roads will be done.

557. As for the future traffic demand, the heavy car trip movement will extend from Centro and its neighbor area to future developed area in sub-urban area and also, the strong desire line by bus will widely extend to all the Study Area. As seen Table 9.1-1 and Figure 9.1-1, the future growth ratio of traffic volume during two decades from 1991 is expected to be 2-3 times in each direction. Especially in northern and southern directions the figures rise by about 10-20 times due to the fact that the present volume is so low. Therefore, the volume-capacity ratio in 2010 exceeds 1.5 in every direction under the present road network system.

Table 9.1-1 Traffic Volume and The Volume-Capacity Ratio in 1991 and 2010

No.	Section	Traffic Volume (PCU)		Ratio	Volume/Capacity	
		1991	2010	2010/1991	1991	2010
1	Bocagrande(1)	44,542	120,894	2.71	0.61	1.66
2	Bocagrande(2)	48,368	120,894	2.50	0.81	2.01
3	Centro	122,782	327,938	2.67	0.77	2.05
4	Screen Line	90,696	304,971	3.36	0.99	3.31
5	Industrial Area	39,556	134,272	3.39	0.52	1.75
6	Central/South Oriental	72,774	216,001	2.97	0.60	1.78
7	Boundary of Urban Area	34,832	119,375	3.43	1.09	3.73
8	Mamonal Industrial Area	16,007	151,710	9.48	1.00	9.48
9	North (Bayunca)	6,565	124,349	18.94	0.23	4.32
10	South-East (Turbaco)	9,986	37,891	3.79	0.62	2.37

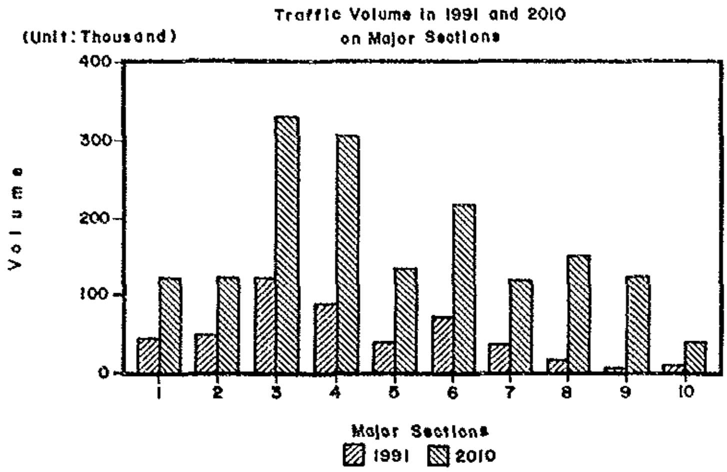


Figure 9.1-1 Traffic Volume on The Imaginary Sections in 1991 and 2010

(2) Road Network Conditions

558. As before-mentioned, at the present the demand and supply are balanced which means that traffic volume and transport facilities are well balanced under the present road network system. The volume-capacity ratio on the busiest traffic corridor in directions of east and west near Mercado (Public Market) will soon exceed 1.0. In future this belt will become the bottleneck of traffic if no action will be taken.

559. Taking into consideration the future traffic demand, the arterial roads must be constructed to increase the road capacity in the urban area. In sub-urban area, new road construction must be planned to meet the future development schemes to handle the generated traffic.

560. As for the collector roads, the road conditions such as alignment, width and pavement are not enough to serve vehicles and public buses. There are many collector roads which are not linked with arterial or other collector roads. It is difficult to steer vehicles and conduct public bus operation on those roads. In future, the improvement of those collector roads to connect residences with the arterial or other collector roads is necessary because of the anticipated increase in car trips by 3.6 times. It is also necessary to improve the collector roads for public bus operation on those roads.

9.2 Road Network Planning

9.2.1 Road Function Highlight

561. The roads in a road network have their own functional features, no matter whether explicit or implicit. According to AASHTO, urban roads are divided into four (4) types of road functional classification, namely 1) Principal arterial street, 2) Minor arterial street, 3) Collector street, and 4) Local street.

562. The arterial roads are required mainly for maintaining mobility function and generally have high road design standards. Local roads are required mainly for maintaining land access and therefore they have low road design standards. The arterial road is to serve mainly for long distance trips, high capacity and high travel speed. Local road is mainly for short distance trips, small capacity and low design speed.

563. Road network system is not only to contribute for development of urban activities, but also to form the basic urban structures.

564. In this Study, the road function was classified into 3 categories; Arterial Road, Collector Road and Local Road. The Collector Road is also divided into 2 categories (Major and Minor). The minor collector roads provide service to travel over relatively short distances as compared to Major Collector Roads. The Local Roads are not studied in the Road Masterplan Study. As for the suburban area, subregional road is categorized as a rural arterial road and is expected to provide relatively high travel speed.

565. In Cartagena, the planning and designing roads can be classified jurisdictionally into the 10 classifications under City Act No. 420 dated on January 2, 1990, taking into account the road function (refer to Table 3.2-4). Therefore, the road network planning criteria, design standards and the typical cross section elements are in accordance with the road classification by the City Act considering the road function defined above.

9.2.2 Future Road Network Configuration

(1) Long Term Plan

566. In this Study, long term road network plan was made based on the following planning goals for solving the transport issues mentioned before;

- To seek economic aspects,
- To utilize existing facilities,
- To keep good environment, and
- To secure traffic safety.

567. The long term plan means the ideal network system in the Study Area not related to whether the projects are completed or not by the target year.

568. In order to embody the planning goals, the following items are taken into account as planning concepts in this Study;

1) Structure of road network,
2) Road function,
3) Demand-supply balance, and
4) Future land use.

569. A future development trend is dependent on the road network structure. The transportation frame is dominated by the arterial roads. The demand-supply balance is important in traffic movement. In this Study, the proposed volume-capacity ratio as a criteria is set at less than 1.0 on each imaginary section. The long term plan was made taking the above into consideration.

570. In Cartagena, there are many existing road plans which have been already studied or are now under study or in the design stage by concerned agencies such as EDURBE and Departamento Administrativo de Valorizacion Distrital, etc. Among them, "Plan De Desarrollo De Cartagena in the target year of 1987-2010" made in 1987 by the municipality of Cartagena is major existing road plan. Some of those roads are now under construction. The road masterplan should be well coordinated with those projects. The long term plan in the Study was made by reviewing and coordinating with existing road plans. Figure 9.2-1 shows the long term plan.

571. Table 9.2-1 shows the summary of long term projects. The total project length is approximately 264 km in the Study Area, of which 157 km involve for new road construction, 90 km are for road improvement and 17 km are for bridge construction. As for new road construction, 90% of the total construction are for arterial/collector roads and the balance is for the minor collector roads. The ratio of length of the arterial/collector roads to the total road improvement is 73%. Almost all the road projects involve arterial roads in order to strengthen the network structure.

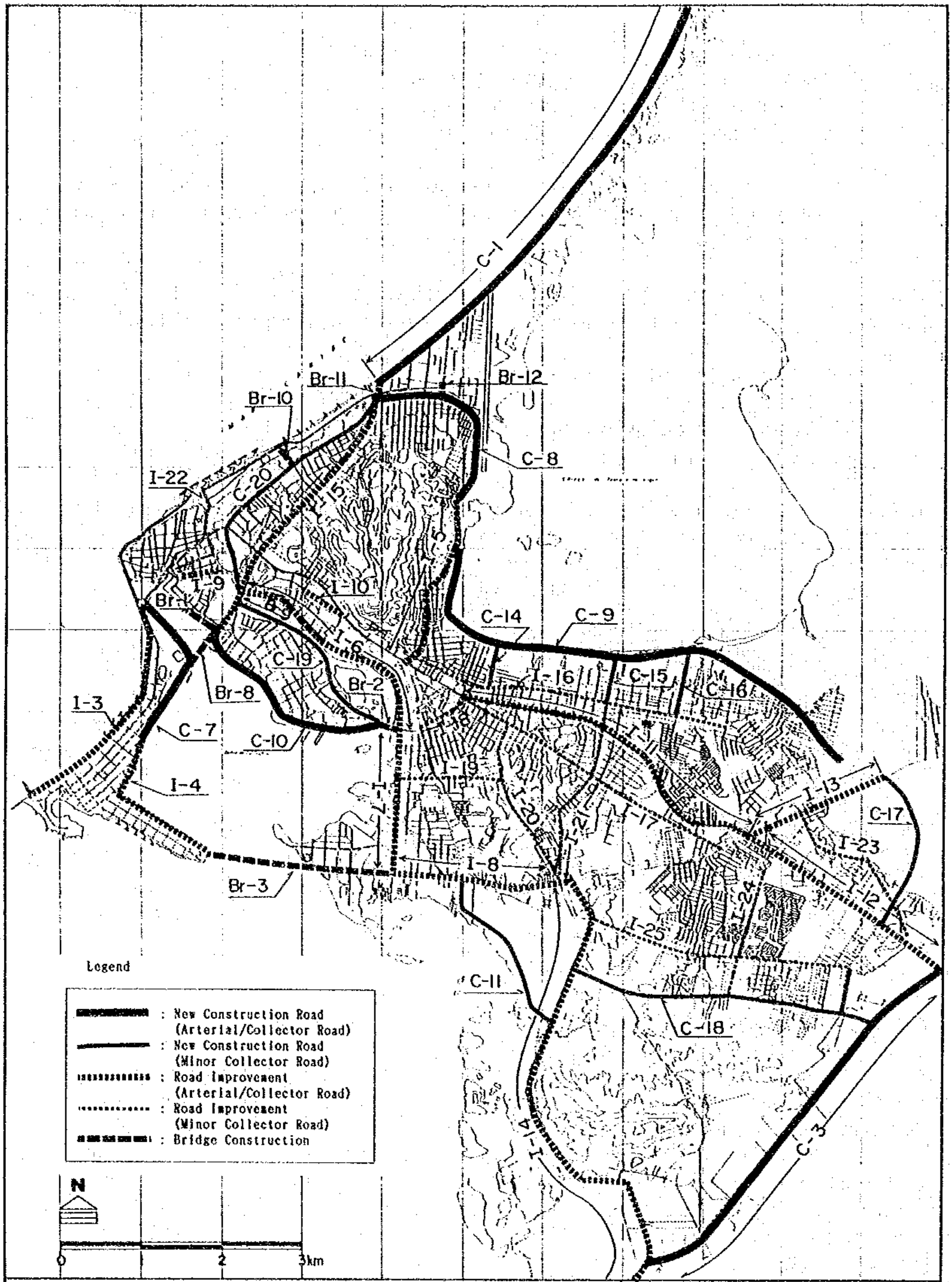


Figure 9.2-1(1) The Long Term Road Plan in Cartagena (Urban Area)

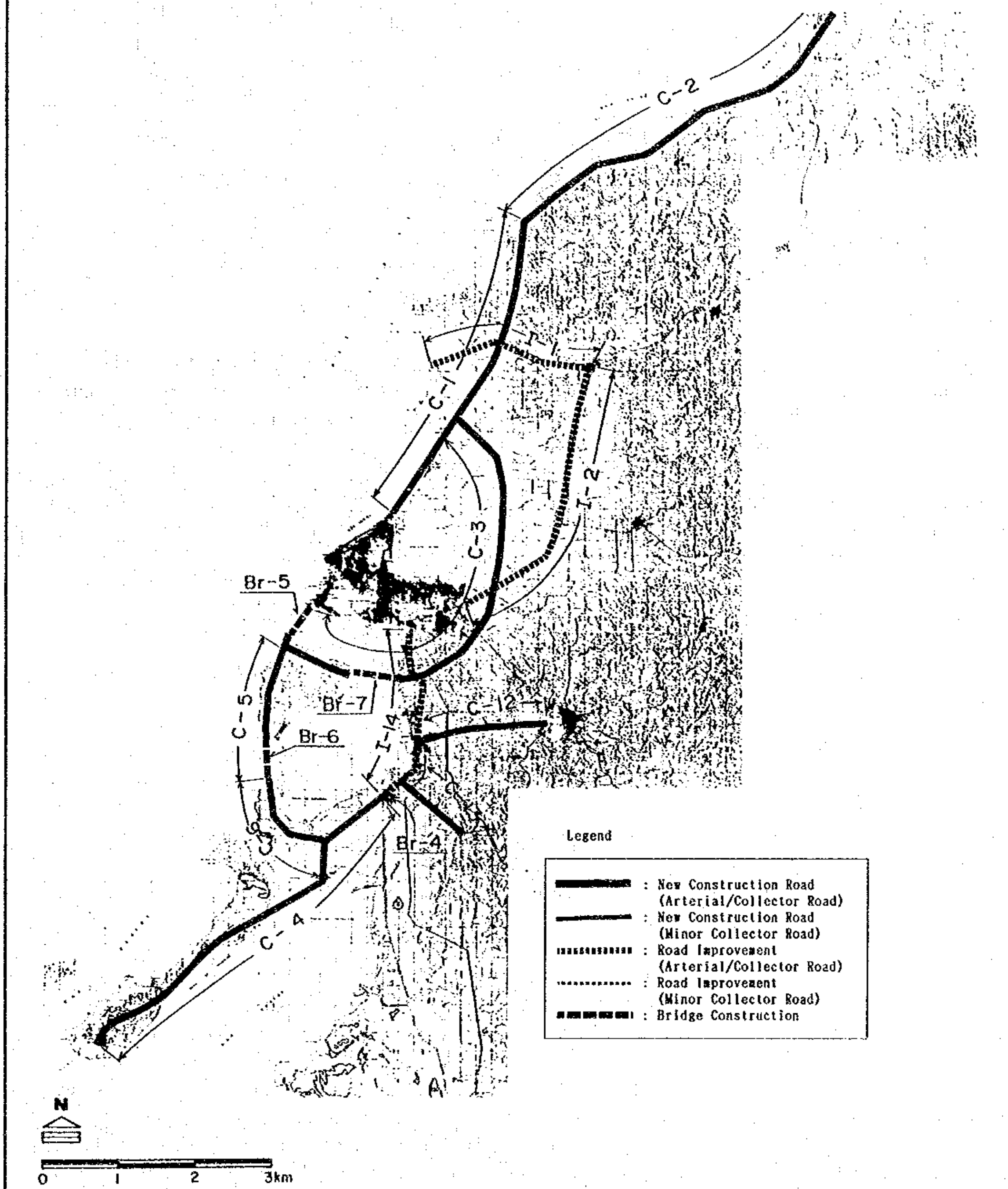


Figure 9.2-1(2) The Long Term Road Plan in Cartagena (Sub-Urban Area)

Table 9.2-1 Summary of Long Term Projects

Items	Length (km)	2 Lanes	4 Lanes	6 Lanes
New Construction Roads				
- Arterial/Collector Roads	140.38	35.24	97.72	7.42
- Minor Collector Roads	16.76	13.65	3.11	0.00
Sub-Total	157.14	48.89	100.83	7.42
Road Improvement				
- Arterial/Collector Roads	67.72	0.00	48.21	19.51
- Minor Collector Roads	22.26	16.78	5.48	0.00
Sub-Total	89.98	16.78	53.69	19.51
Bridge Construction	16.80	0.84	15.96	0.00
Total Length	263.92	66.51	170.48	26.93

572. Figure 9.2-2 shows the road function in the network system. As seen, the following roads in the urban area are newly defined as arterial roads together with Pedro de Heredia. The first group forms a ring road along the Bay of Cartagena. This ring road together with Av. Jacobo del Valle strengthens the supply of capacity on the busiest traffic corridor in direction of east and west. The second group represents the links to the Mamonal Industrial Area where the large scale development is planned. The last group connects to the large scale development area in the northern part of the Study Area.

- Av. Miramar/ Navy Base Road/ Calle 6/ Diagonal 20 / Manzanillo Bridge
- Transversal 54/ Diagonal 30
- Anillo Vial Road/ Carretera del Mar Road (Bocacanoa-Palmarito)

573. The collector roads consist of the following;

- Cienaga de la Virgen Road/Carrera 17, and
- Av. Jacobo del Valle.

Those roads also handle traffic into Centro. Especially, Av. Jacobo del Valle strengthens the traffic movement on the heavy traffic corridor together with Av. Miramar and Pedro de Heredia.

574. The total road length of all types of roads in the Study Area in the long term plan is approximately 340 km, of which 115 km are for arterial and collector roads and the balance is for minor collector and rural roads. The future road length for all types represents 1.6 times the current system (refer to Table 9.2-2).

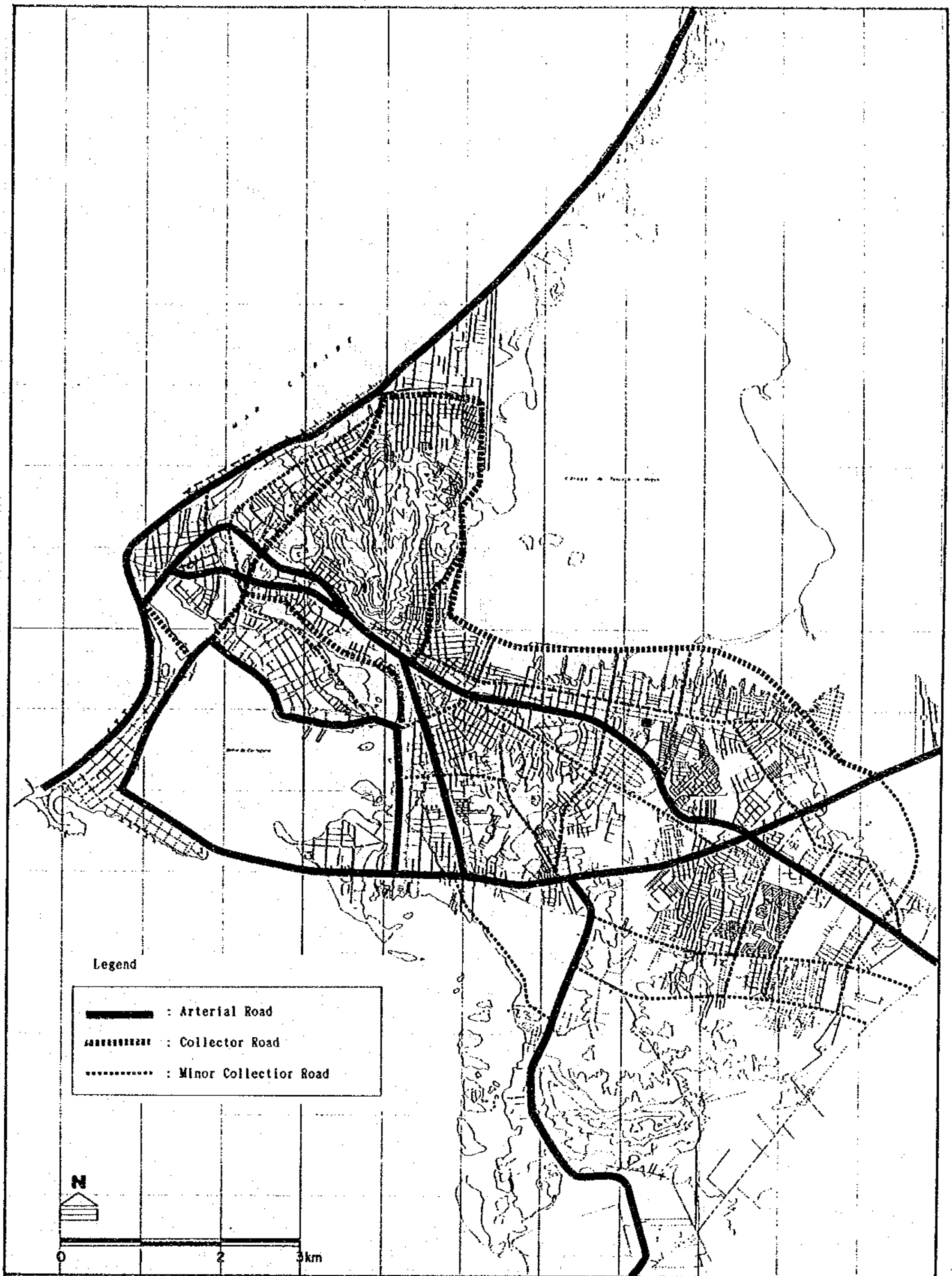


Figure 9.2-2(1) The Road Function in the Long Term Plan (Urban Area)

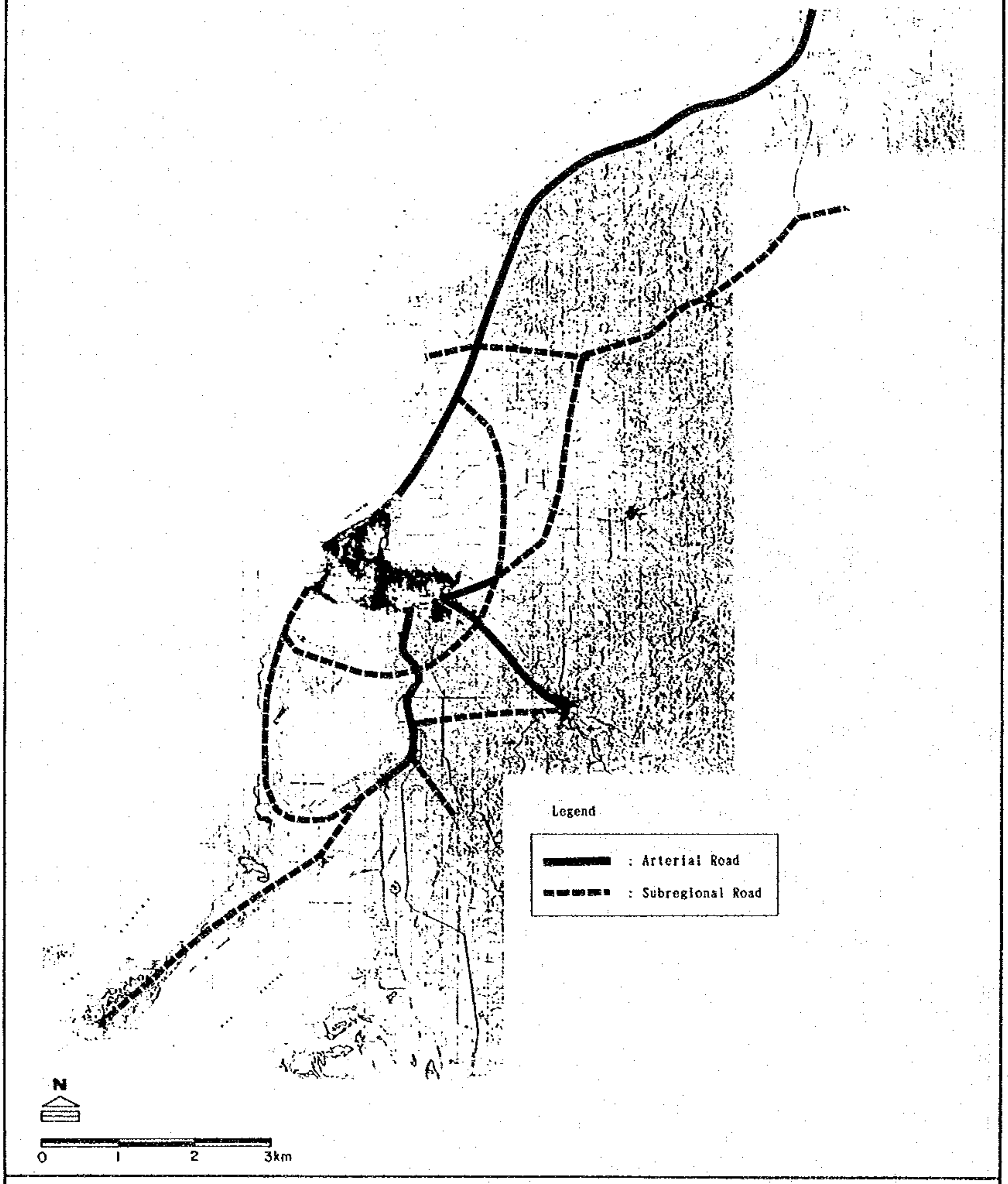


Figure 9.2-2(2) The Road Function in the Long Term Plan (Sub-Urban Area)

Table 9.2-2 Road Length by Integrated Zones

Int. Zone	Arterial/Collectors (km)			All Road (km)			Arter-Collect/Cars (km/1000cs)			All Road/Cars (km/1000Cars)		
	1991 Net	2010 Net	Long Term	1991 Net	2010 Net	Long Term	1991 Net	2010 Net	Long Term	1991 Net	2010 Net	Long Term
1	4.09	11.95	11.94	12.16	18.05	18.05	1.111	1.132	1.131	3.302	1.710	1.710
2	10.41	12.69	12.69	16.33	17.84	17.84	3.239	1.295	1.295	5.081	1.820	1.820
3	2.8	6.67	6.67	3.48	7.34	7.34	7.053	6.578	6.578	8.766	7.239	7.239
4	6.36	11.04	11.97	11.6	14.96	14.11	4.321	1.787	1.938	7.880	2.422	2.284
5	5.59	8.88	8.88	8.73	12.07	12.01	2.492	0.730	0.730	3.892	0.993	0.988
6	5.19	7.31	7.31	6.95	9.41	9.41	22.763	9.312	9.312	30.482	11.987	11.987
7	3.96	6.59	6.95	4.65	8.44	9.62	26.053	7.258	7.654	30.592	9.295	10.595
8	4.47	5.37	5.52	5.16	6.06	7.18	30.616	4.391	4.513	35.342	4.955	5.871
9	1.84	1.84	1.84	2.2	2.71	2.71	2.570	1.061	1.061	3.073	1.563	1.563
10	0	1.03	1.03	6.04	8.79	8.79	0.000	0.540	0.540	8.948	4.612	4.612
11	4.34	6.05	6.06	7.55	9.95	9.95	9.644	5.302	5.311	16.778	8.720	8.720
12	3.68	8.01	11.77	6.82	9.8	9.8	3.702	3.611	5.307	6.861	4.418	4.418
13	5.8	9.82	9.82	8.02	13.88	17.8	7.923	3.148	3.148	10.956	4.450	5.707
14	2.73	2.73	2.73	8.95	10.02	10.69	2.457	1.109	1.109	8.056	4.070	4.342
15	6.66	9.33	9.33	15.74	23.1	25.39	9.652	2.948	2.948	22.812	7.299	8.022
16	0	0	0	26.38	50.49	50.49	0.000	0.000	0.000	0.000	7.924	7.924
17	0	0	0	24.74	32.61	32.61	0.000	0.000	0.000	1546.250	47.398	47.398
18	0	0	0	6.42	21.98	25.52	0.000	0.000	0.000	401.250	18.002	20.901
19	0	0	0	0	7.13	15.9	0.000	0.000	0.000	0.000	20.607	45.954
20	0	0	0	25.63	25.63	35.76	0.000	0.000	0.000	0.000	55.356	77.235
Total	67.92	109.31	114.51	207.55	310.26	340.97	4.011	1.620	1.697	12.256	4.599	5.054

575. The planned road length by the integrated zones is shown in Figure 9.2-3 in which the future road lengths for the long term plan and 2010 Masterplan are compared with those at the present. The road lengths are classified into "All Roads" (including minor collector and sub-urban road) and "Arterial/Collector Roads". As for arterial and collector roads, the zones with the high increase ratio of road length are Int. zone Nos.1, 5, 12 and 13 which surround the bay of Cartagena. Int. zone Nos.3, 6 and 7 to surround Cienaga de Tesca (swamp) also show an increase in planned length. Those figures fluctuate in range of 1.5 and 3.0. The Int. zone Nos.16 and 18 inside the sub-urban area have higher planned road lengths of sub-urban roads (see All Type Roads in Figure 9.2-2).

576. Road length of all classifications per number of cars in the Study Area falls from approximately 12.2km/1000cars at the present to 5.1km/1000cars in future. Those figures of future arterial and collector roads are also low at 1.7km/1000cars, in contrast to 4.0km/1000cars at the present (refer to Table 9.2-2).

577. Figure 9.2-4 shows the road length per 1000cars by the integrated zones. As seen, those lengths in Int. zone Nos.5, 6, 7 and 8 are somewhat less due to the fact that the planned road length is relatively short compared to the future growth ratio of cars.

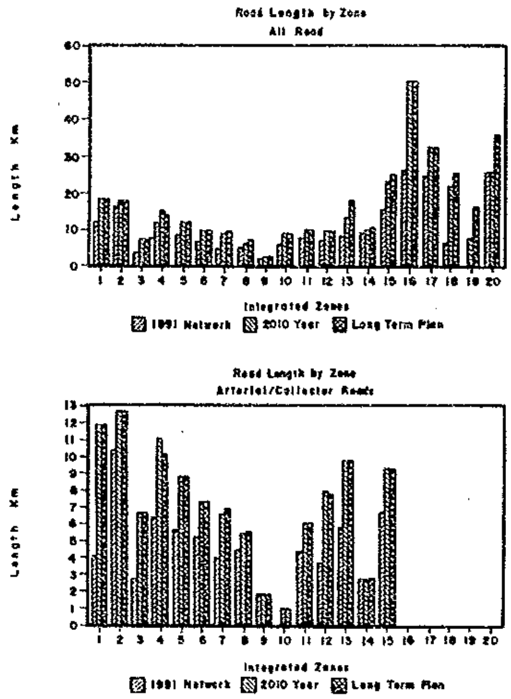


Figure 9.2-3 Planned Road Length by Integrated Zones

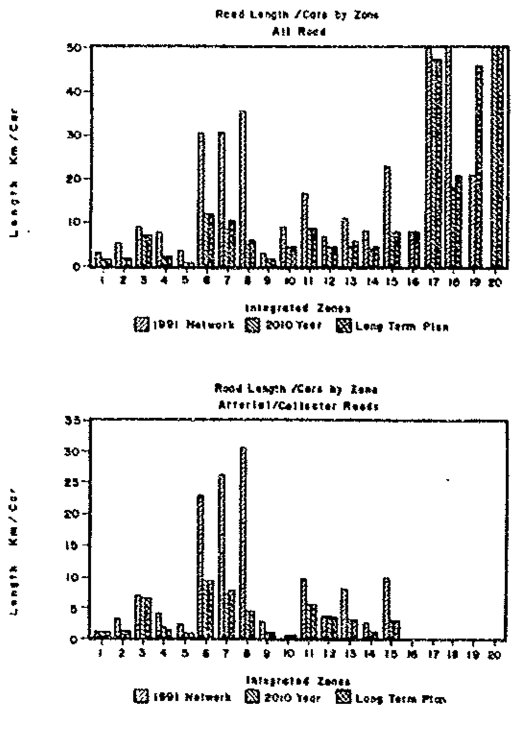


Figure 9.2-4 Planned Road Length per Cars by Integrated Zones

578. The demand-supply balance on the imaginary sections in this long term plan is shown in Table 9.2-3 which is compared to "Do-Nothing case". The demand and supply are well balanced in every direction (refer to Figure 3.3-10) under the long term plan.

Table 9.2-3 Traffic Volume and Volume-Capacity in Long Term Plan

No.	Section	Traffic Volume		Volume-Capacity	
		Do-Nothing	Full Net	Do-Nothing	Full Net
1	Bocagrande(1)	120,894	109,442	1.66	0.65
2	Bocagrande(2)	120,894	109,442	2.01	0.91
3	Centro	327,938	235,673	2.05	0.82
4	Screen Line	304,971	248,535	3.31	0.89
5	Industrial Area	134,272	97,843	1.75	0.87
6	Central/South Oriental	216,001	137,068	1.78	0.65
7	Boundary of Urban Area	119,375	72,036	3.73	0.66
8	Mamonal Industrial Area	151,710	73,404	9.48	1.02
9	North (Bayunca)	124,349	125,222	4.32	1.04
10	South-East (Turbaco)	37,891	144,526	2.37	0.86

579. Figure 9.2-5 shows the ratio of road length by level of the volume-capacity ratio according to four road/traffic conditions: a) 1991 road/traffic conditions, b) Do-nothing case (1991 network/2010 traffic conditions), c) the long term network/2010 traffic conditions and d) 2010 Masterplan network/2010 traffic conditions. The volume-capacity ratio is classified into 3 levels: less than 1.0, less than 1.5 and 1.5 or over. At the present 98% of the total length are less than 1.0 in the v/c ratio. In Do-nothing case the figure falls to 27%, while road sections with the v/c ratio 1.5 or over sharply rise at 57%. In the long term plan, those levels will be close to the present conditions, though traffic conditions in terms of v/c ratio are somewhat poor compared to those at the present.

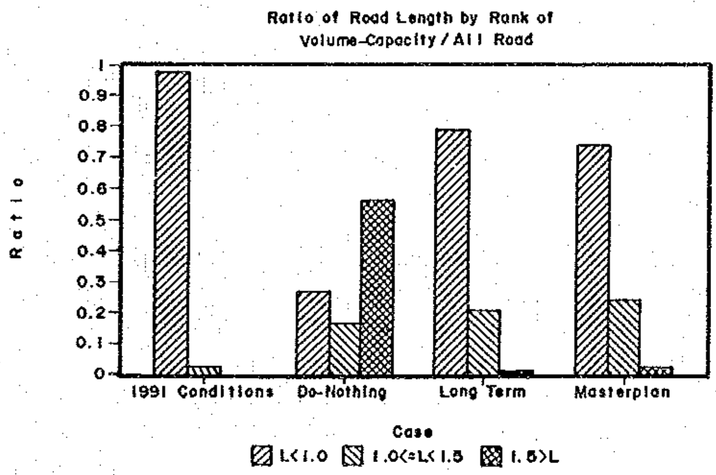


Figure 9.2-5 Ratio of Road Length by Volume-Capacity Ratio

580. Traffic conditions in terms of the average volume-capacity ratio and the average travel speed by three cases; 1991 road/traffic conditions, Do-nothing case, the long term network/2010 traffic conditions, are shown in Table 9.2-4. The average v/c ratio in the long term plan is maintained with less than 1.0, in contrast to 2.3 for Do-nothing case. The average travel speed in the long term plan is found to retain the present level with about 40 km/hr. Those discussions indicate that the long term network plan is close to the planning goal/criteria which sets the v/c ratio at less than 1.0.

Table 9.2-4 Traffic Conditions by Road Network Cases

Items	1) 1991	2) Do-Nothing in 2010	3) Long Term in 2010	Increase Ratio 2)/1)	3)/1)
Average Volume-Capacity Ratio					
1) Study Area	0.32	2.25	0.60	7.06	1.89
2) Urban Area	0.46	2.24	0.61	4.89	1.34
Average Travel Speed					
1) Study Area	41.5	11.8	43.8	0.29	1.06
2) Urban Area	39.4	11.5	37.6	0.29	0.95

(2) Road Projects

581. The type of road projects in the Long Term Plan is classified into 3 types; New Road Construction, Bridge Construction and Road Improvement by road function.

582. Table 9.2-5 shows the outline of road projects in the new road construction. The total lengths of the arterial and collector roads are approximately 140 km (exclusive of bridge length). Of these, 130 km, equivalent to 93% to the total, are outside the urban area. Those roads are planned as 4 lane roads. Those road projects need bridge construction due to the geographical constraints of islands included in the Study Area: Tierra Bomba and Baru islands, as shown in Table 9.2-6. The total length of bridges over these islands are approximately 12 km including approach roads.

583. Almost all of the road projects are planned outside the urban area as shown in Tables 9.2-5 and 9.2-6 due to the large scale development of residential area to be located on the northern part of the Study Area and to the large scale industrial area which is planned on Mamonal Industrial Area, as well as due to the fact that roads are few in the sub-urban area at the present.

584. In the urban area, the following projects are mainly

planned to strengthen the heaviest traffic corridor in direction of east and west;

- Av. Miramar,
- Navy Base Road,
- Manzanillo Bridge, and
- Las Animas Bridge.

585. Through the bridge construction, it is hoped that traffic movement to Centro will divert from Pedro de Heredia to Manga or Boca Grande by using both bridges and as a result, traffic load on Pedro de Heredia will be alleviated.

586. The road improvement projects are shown in Table 9.2-7. The total lengths of arterial and collector roads are approximately 70 km. The percentage of road improvement length in the urban area is about 60%. The share of urban area is higher than that in the sub-urban area. Widening the number of lanes is mainly implemented under road improvement. Among the major projects are the widening from 2 lanes to 4 lanes on Calle 30 near Pie de la Popa and Media Luna (I-9 and I-10), widening from 2 to 4 lanes on Av. Jacobo del Valle (I-6), and widening from 2 to 6 lanes on Diagonal 30 (I-14), etc. The main purpose of those projects is to strengthen the road capacity on the Pedro de Heredia's corridor by the widening of Calle 30 and Av. Jacobo del Valle. The corridor to the Mamonal Industrial Area will also be strengthened by improving Diagonal 30 where the widening alleviates the estimated future traffic congestion in the Mamonal Industrial Area, and by construction of the new road: Ceballos Road (C-11).

Table 9.2-5 Road Projects for New Road Construction

New Construction/ Arterial and Collector Roads

Pr.No.	Name	Length(km)	Remarks
C-1	Anillo Vial Road (Aeropuerto-Bocacanoa)	22.32	4/6 lanes/under constr.
C-2	Carretera del Mar Road (Bocacanoa-Palmarito)	23.78	4 lanes
C-3	Anillo Vial-Bocachica-Carretera del Mar Road	28.90	4 lanes
C-4	Trans-Baru Road	25.10	2/4 lanes
C-5	Baru-Tierra Bomba Road	5.85	4 lanes
C-6	Nao-Ararca Road	8.59	4 lanes
C-7	Navy Base Road	1.50	4 lanes
C-8	Juan Angola Road	2.68	4 lanes
C-9	Cienaga de la Virgen Road	5.92	4 lanes
C-10	Avenida Miramar Road (Pasteliollo-Bazurto)	2.67	4 lanes
C-12	Canteras Road (Puerto Bombero-Turbaco)	9.47	2 lanes
C-13	Camino a Turbana Road	3.60	2 lanes
	Sub-Total	140.38	

New Construction/ Minor Collector Roads

Pr.No.	Name	Length(km)	Remarks
C-11	Ceballos Road	2.19	4 lanes
C-14	Boston Road (Carrera 44)	0.53	2 lanes
C-15	Carrera 51 (Rafael Nunez)	0.58	2 lanes
C-16	Carrera 59 (Olaya Herrera)	0.89	2 lanes
C-17	Ternera-Ladrillera Road	2.27	2 lanes
C-18	Campestre-Anillo Vial Road	4.55	2 lanes
C-19	5th Av. Manga	2.25	2 lanes
C-20	Chambacu Road	3.5	2 lanes
	Sub-Total	16.76	

Table 9.2-6 Road Projects for Bridge Construction

Pr.No.	Name	Length(km)	Remarks
Br-1	San Lorenzo Bridge	0.20	2 lanes including approach
Br-2	Bazurto 2 Bridge	0.32	2 lanes including approach
Br-3	Manzanillo Bridge	2.70	4 lanes including approach
Br-4	Pasacaballo Bridge	1.05	4 lanes including approach in Project No. C-4
Br-5	Escollera Bridge	2.56	4 lanes including approach in Project No. C-3
Br-6	Bocachica Bridge	3.08	4 lanes including approach in Project No. C-5
Br-7	Cartagena Bay Bridge	5.17	4 lanes including approach in Project No. C-3
Br-8	Las Animas Bridge	0.60	4 lanes including approach
Br-9	Las Palmas Bridge	0.21	4 lanes including approach in Project No. I-15
Br-10	Marbella Bridge	0.32	2 lanes including approach
Br-11	Canapote Bridge	0.10	4 lanes including approach
Br-12	Crespo Bridge	0.10	4 lanes including approach
Br-13	Heredia Bridge	0.39	4 lanes including approach
	Total	16.80	

587. The road improvement projects on the minor collector road are also shown in Table 9.2-7. The improvement length is approximately 23 km. Those projects are inside the urban area. The pavement on the road surface and widening to 2 lanes are planned to be able to improve the driving conditions for cars and public buses on those roads.

Table 9.2-7 Road Improvement Projects

Improvement / Arterial and Collector Roads

Pr.No.	Name	Length(km)	Remarks
I-1	Bayunca-P.Canoas Road	8.11	From 2 to 4 lanes
I-2	Ladrillera-Bayunca Road	18.26	From 2 to 4 lanes
I-3	Carrera 1 (Bocagrande)	2.64	From 2 to 4 lanes and 4 to 6 lanes
I-4	Calle 6 (C/Grand)	2.13	From 2 to 4 lanes
I-5	Carrera 30 (San Francisco-Quinta)	2.05	From 2 to 4 lanes
I-6	Avenida Jacobo del Valle	2.88	From 2 to 4 lanes
I-7	Diagonal 20/ Bosque	1.80	From 2 to 4 lanes
I-8	Transversal 54/ Bosque	2.29	From 2 to 4 lanes and 4 to 6 lanes
I-9	Calle 30 (Media Luna)	0.46	From 2 to 4 lanes
I-10	Calle 30 (Piede la Popa)	0.59	From 2 to 4 lanes
I-11	Av. Pedro de Heredia	4.26	From 4 to 6 lanes
I-12	Amplicacion Troncal Sta.Lucia-Temera	3.66	From 2 to 4 lanes
I-13	Transversal 54 (Amparo-Ladrillera)	1.90	From 2 to 4 lanes
I-14	Diagonal 30 (Ceballo-Mamonal)	13.42	From 2 to 6 lanes
I-15	Carrera 17	3.27	From 2 to 4 lanes
			From 2 to 4 lanes
	Sub-Total	67.72	

Improvement/ Minor Collector Roads

Pr.No.	Name	Length(km)	Remarks
I-16	Avenida Pedro Romero	4.21	From 2 to 4 lanes
I-17	Av. El Consulado/Piedra de Bolivar-Hospital	3.85	2 lanes, pavement
I-18	Calle de Matadero	0.65	From 2 to 4 lanes
I-19	Transversal 45 (Juan 23)	1.25	2 lanes, pavement
I-20	Carrera 46 (Ceballo-Espana)	2.32	2 lanes, pavement
I-21	Carrera 51 (Nuevo Bosque-Costa Linda)	2.13	2 lanes, pavement
I-22	Calle 41 (Av.Santander-India Catalina)	0.62	From 2 to 4 lanes
I-23	Antigua via Ternera	2.16	2 lanes, pavement
I-24	Carrera 71 (El Socorro-Biffi)	1.69	2 lanes, pavement
I-25	Calle 15 (Santa Clara-San Fernando)	3.38	2 lanes, pavement
	Sub-Total	22.26	

9.3 Cost Estimate

588. Project cost was estimated by each road project listed above. The project cost consists of the following items.

(1) Direct construction cost
  - Labor cost
  - Material cost
  - Equipment cost

(2) Indirect cost
  - Administration cost
  - Engineering service cost
  - Contingencies

(3) Land acquisition and Compensation costs

589. The cost data for road projects were obtained from EDURBE and related agencies of the Colombian government and were used to estimate the project cost. As for bridge construction cost, the data collected from the related agencies was used. The data was arranged in form of unit cost by main working items. The project cost was estimated by multiplying road construction quantities by the unit cost of main working items. The estimated price is in Pesos (Ps$) as of March 1992.

9.3.1 Road Construction Cost

(1) Direct Construction Cost

590. The unit cost of road construction cost by main working items is shown in Table 9.3-1 which is in Pesos (Ps$) as of March 1992, obtained from EDURBE. This unit cost includes labor cost, equipment cost, material cost and taxes.

Table 9.3-1 Construction Work Unit Cost

List of Road Construction Cost on March 4, 1992
From EDURBE

No.	Discription	Unit	Unit Price ($ Pesos)	Remarks
1	Excavation of Soil			
	- Dry Soil/Earth	m3	4,106	
	- Wet Soil/Earth	m3	3,123	
2	Banking Works (Fill with Fine Materials)	m3	7,556	
3	Fill with Coarse Materials) (near sea shore)	m3	5,804	
4	Concrete Pavement (h=0.25m)	m2	20,311	H=7.0 cm
5	Granular Sub-Base	m3	7,556	H=40-60 cm
6	Granular Base	m3	11,365	H=20 cm
7	Concrete Asphalt	m3	59,699	
8	Drainage Works	m	5,439	
9	Traffic Sign	Unit	10,000	
10	Paint	m	700	
11	Shore Protection	m	100,000	
12	Overlay	m2	15,500	
13	Lighting			
	- Double Lighting	km	26,000,000	
	- Single Lighting	km	19,000,000	
14	Sidewalk	m2	5,578	

(2) Indirect Cost

591. The indirect cost includes Administration cost, Engineering service cost and Contingencies. A percentage of direct construction cost is applied as the indirect cost. In the Colombian government, 2-7% of the total direct construction cost are assumed for the design stage. In this Study, however, those values were raised to 10% taking into account the masterplan stage.

- Administration cost (10% of construction cost)
- Engineering service cost (10% of construction cost)
- Contingencies (10% of construction cost)

(3) Land Acquisition and Compensation Costs

592. The land price in March 1992 was obtained from the real estate broker. The compensation cost data along the planned road alignment was collected from Municipality of Cartagena. The land price and compensation costs was estimated by each road project.

593. In the project cost, it is assumed that land acquisition and compensation costs will be paid only for private land, not for public land such as military base and government owned. As for the economic analysis of the projects, the public lands are considered as other used spaces, and therefore, an opportunity cost is applied to them.

(4) Project Cost Estimate for Road Construction

594. The direct construction cost was estimated by multiplying road construction quantities by the unit cost of main working items. The indirect cost included the total of three indirect items. The estimated project cost is shown in Table 9.3-2 for new road construction project and Table 9.3-3 for road improvement project. As seen, the total construction cost for the Masterplan project is approximately 194 billion Pesos, of which 108 billion Pesos are for new road construction projects and 86 billion Pesos are for road improvement projects.

9.3.2 Bridge Construction Cost

595. The bridge construction cost depends on the type of bridge and its length (span). In this Masterplan Study, the type of bridge is not finally determined, however, the cost estimate was conducted on the assumption that the type of bridge for every bridge project is PC Concrete Bridge, exclusive of Br-3, Manzanillo Bridge, being Cable Stay Bridge. Schematic plans of these Projects are shown in Appendix 9-1.

Table 9.3-2 Project Cost for New Road Construction

New Construction Project Costs

Pr. No.	Lane	Class	Length (km)	Direct Cost ($ M. Ps) Construction Cost	Land Aquisitio Cost	Compensation	Sub-Total Construction	Indirect Cost ($ M. Ps) Administration Cost (10%)	Engineering Services (10%)	Contingency (10%)	Project Cost
C-1	6	V-2	7.42	7,528	1,076	0	8,603	752	752	752	10,859
	4	V-2A	14.9	11,633	1,639	0	13,272	1,163	1,163	1,163	16,761
C-2	4	V-2A	23.78	13,062	2,616	0	15,678	1,306	1,306	1,306	19,596
C-3	4	V-1	21.34	8,757	4,972	0	13,729	875	875	875	16,354
C-4	2	V-1A	25.1	5,823	1,669	0	7,491	582	582	582	9,237
C-7	4	V-2A	1.5	776	0	0	776	77	77	77	1,007
C-8	4	V-3	1.8	1,005	2,880	0	3,885	100	100	100	4,185
	2	V-4	0.88	404	1,162	72	1,637	40	40	40	1,757
C-9	2	V-4	5.92	2,792	2,930	100	5,822	279	279	279	6,659
C-10	4	V-2A	1.44	814	0	0	814	81	81	81	1,057
	4	V-2A	1.23	563	1,213	0	1,776	56	56	56	1,944
C-12	2	V-1A	2.39	505	159	0	664	50	50	50	814
C-13	2	V-1A	3.6	729	239	0	968	72	72	72	1,184
C-11	4	V-3	2.19	1,064	876	0	1,940	106	106	106	2,258
C-14	2	V-4	0.53	169	128	333	630	16	16	16	678
C-15	2	V-4	0.58	179	128	333	640	17	17	17	691
C-16	2	V-4	0.89	288	203	679	1,170	28	28	28	1,254
C-18	2	V-4	1.55	410	165	341	916	41	41	41	1,039
C-19	2	V-4	2.25	1,031	3,713	0	4,744	103	103	103	5,053
C-20	4	V-3	0.92	466	0	0	466	46	46	46	604
	2	V-4	2.58	1,186	3,406	0	4,592	118	118	118	4,946
Total			122.79	59,184	29,174	1,858	90,216	5,908	5,908	5,908	107,940

Table 9.3-3 Project Cost for Road Improvement

Road Improvement Project Costs

Pr. No.	Lane	Class	Length (km)	Direct Cost ($ M. Ps) Construction Cost	Land Aquisitio Cost	Compensation	Total Construction	Indirect Cost ($ M. Ps) Administration Cost (10%)	Engineering Services (10%)	Contingency (10%)	Project Cost
I-2	4	V-1	18.26	13,393	1,621	128	15,143	1,339	1,339	1,339	19,160
I-3	4	V-2A	2.23	627	0	0	627	62	62	62	813
	6	V-2	0.41	196	0	0	196	19	19	19	253
I-4	4	V-2A	2.13	715	0	0	715	71	71	71	928
I-5	4	V-3	2.05	859	1,297	408	2,564	85	85	85	2,819
I-6	4	V-3	2.88	770	0	0	770	77	77	77	1,001
I-7	4	V-2A	1.8	618	790	492	1,899	61	61	61	2,082
I-8	4	V-2A	0.87	312	137	296	745	31	31	31	838
	6	V-2	1.42	589	681	716	1,986	58	58	58	2,160
I-9	4	V-2A	0.46	128	551	3,450	4,129	12	12	12	4,165
I-10	4	V-2A	0.59	183	372	1	556	18	18	18	610
I-11	6	V-2	4.26	837	761	4,372	5,969	83	83	83	6,218
I-12	4	V-2A	3.66	1,353	0	0	1,353	135	135	135	1,758
I-13	4	V-2A	1.9	703	0	0	703	70	70	70	913
I-14	6	V-2	13.42	7,816	1,193	104	9,113	781	781	781	11,456
I-15	4	V-3	3.27	816	1,259	2,244	4,319	81	81	81	4,562
I-16	4	V-3	4.21	1,586	999	1,312	3,896	158	158	158	4,370
I-17	2	V-4	3.85	953	716	4,050	5,720	95	95	95	6,005
I-18	4	V-3	0.65	245	154	444	843	24	24	24	915
I-19	2	V-4	1.25	254	186	576	1,015	25	25	25	1,090
I-20	2	V-4	2.32	673	498	737	1,908	67	67	67	2,109
I-21	2	V-4	2.13	705	335	1,426	2,466	70	70	70	2,676
I-22	4	V-3	0.62	152	338	0	490	15	15	15	535
I-23	2	V-4	2.16	566	346	0	912	56	56	56	1,080
I-24	2	V-4	1.69	454	83	256	793	45	45	45	928
I-25	2	V-4	3.38	886	541	1,664	3,091	88	88	88	3,355
Total			81.87	36,390	12,855	22,678	71,923	3,626	3,626	3,626	82,801

(1) Direct Construction Cost

596. The unit cost of bridge construction cost by main working items is shown in Table 9.3-4 which is in Pesos (Ps$) as of March 1992, obtained from the related agencies in the Colombian government. This unit cost includes labor cost, equipment cost, material cost and taxes.

Table 9.3-4 Construction Work Unit Cost for Bridge

Bridge Construction Cost

Items	Unit	Unit Price (Pesos)	Remarks
Super Structure			
1) Pavement	m2	5,500	
2) Sidewalk	m2	7,000	
3) Railing	m	15,500	
4) Concrete	m3	125,000	
5) Re-Bar	ton	443,000	
6) PC-Tendon	t-m	330	
7) Steel Plate	ton	2,250,000	For Cable Stay Bridge
8) Cable	ton	3,000,000	For Cable Stay Bridge
9) Errection Grid	v-m	4,900,000	For Cantilever Bridge
10) Assembly	time	5,500,000	For Cantilever Bridge
11) Movement	time	96,000	For Cantilever Bridge
Sub-Structure			
12) Concrete	m3	100,000	
13) Re-Bar	ton	443,000	
14) Excavation	m3	6,000	
15) Steel Pile	ton	1,300,000	

(2) Project Cost Estimate for Bridge Construction

597. The direct construction cost was estimated in the same manner as that of road project. The direct construction cost includes Contingency cost which is assumed as 10% of the direct bridge construction cost. The indirect cost such as Administration Cost and Engineering Service Cost was assumed as a total of thirty percent (30%) of the direct cost.

598. Table 9.3-5 shows the estimated bridge construction cost inclusive of the cost for approach roads. In this Table, Br-5, Br-6 and Br-7 projects are not listed, because they are not included in the 2010 year's Masterplan. The total construction cost is approximately 80 billion Ps$. The Br-3 project cost is higher than others and its cost is approximately 57 billion Ps$, equivalent to 71% to the total bridge cost because this bridge is designed as Cable Stay Bridge with long span. On the other hand, the sum of the remaining 9 projects is approximately 23 billion Ps$.

Table 9.3-5 Project Cost for Bridge

Bridge Construction Cost

Pr. No.	Name	Type of Bridge	Direct Cost (M. Ps$)					Indirect Cost (M. Ps$)	Project Cost (M. Ps$)
			Super-Structure	Sub-Structure	Sub-Total	Contin-gency (10%)	Total	(30%)	
Br-1	San Lorenzo Bridge	PC-Concrete	865.9	710.0	1,575.9	157.6	1,733.5	520.1	2,253.6
Br-2	Bazurto 2 Bridge	PC-Concrete	283.1	206.5	489.6	49.0	538.6	161.6	700.1
Br-3	Manzanillo Bridge	Cable Stay Br.	29,853.8	9,897.5	39,751.2	3,975.1	43,726.4	13,117.9	56,844.3
Br-4	Pasacaballo Bridge	PC/Cantilever Br.	2,370.7	297.9	2,668.6	266.9	2,935.4	880.6	3,816.0
Br-8	Las Animas Bridge	PC/Cantilever Br.	5,197.3	2,216.8	7,414.1	741.4	8,155.5	2,446.7	10,602.2
Br-9	Las Palmas Bridge	PC-Concrete	283.1	550.5	833.6	83.4	917.0	275.1	1,192.1
Br-10	Marbella Bridge	PC-Concrete	814.4	107.7	922.2	92.2	1,014.4	304.3	1,318.7
Br-11	Canapote Bridge	PC-Concrete	814.4	107.7	922.2	92.2	1,014.4	304.3	1,318.7
Br-12	Crespo Bridge	PC-Concrete	814.4	107.7	922.2	92.2	1,014.4	304.3	1,318.7
Br-13	Heredia Bridge	PC-Concrete	283.1	206.5	489.6	49.0	538.6	161.6	700.1
	Total		41,580.3	14,408.8	55,989.2	5,598.9	61,588.1	18,476.4	80,064.5

9.4 Alternatives of the Road Network

9.4.1 Road Masterplan in 2010

599. The road masterplan in the target year of 2010 was prepared based on traffic demand in 2010. The 2010 year's OD trips were assigned on the road network in the long term plan, and the road projects in the road masterplan were selected from those in the long term plan according to the results of traffic assignment. At this stage, this masterplan is set as a basic case (Case-1), involving some projects selected as high priority projects only from a traffic point of view without taking into consideration the socioeconomic aspects.

600. In order to evaluate an optimized road masterplan in 2010 from every aspect such as traffic and cost-benefit, five (5) alternatives were also prepared based on this basic-case-masterplan. Finally, one (1) alternative was chosen as the most effective plan taking into consideration traffic and cost-benefit estimates.

601. The basic case road masterplan in 2010 is shown in Figure 9.4-1. Table 9.4-1 also shows the summary of selected projects in this road masterplan in 2010. The planned total road length is approximately 211 km, of which 129 km (inclusive of 6 km for bridge construction) is for new road construction and 82 km is for road improvement. The ratio of project length in the masterplan to that in the long term plan will be about 80%. This is because new construction roads across the Baru and Tierra Bomba Islands (refer to paragraph No.607) are suspended.

602. The projects outside the urban area were excluded from the long term plan, which includes the following: (refer to Tables 9.4-2 to 9.4-4).

- C- 3: Anillo Vial-Bocachica-Carretera del Mar Road
  including Br-5: Escollera Bridge and Br-7: Cartagena Bay Bridge (only a part over the sea)
- C- 4: Trans-Baru Road
  (to be planned with provisional 2 lane in the Masterplan)
- C- 5: Baru-Tierra Bomba Road
  including Br-6: Bocachica Bridge
- C- 6: Nao-Ararca Road
- C-12: Canteras Road (Puerto Bombero-Turbaco)
- C-13: Camino a Turbana Road
- I- 1: Bayunca-P.Canoas Road

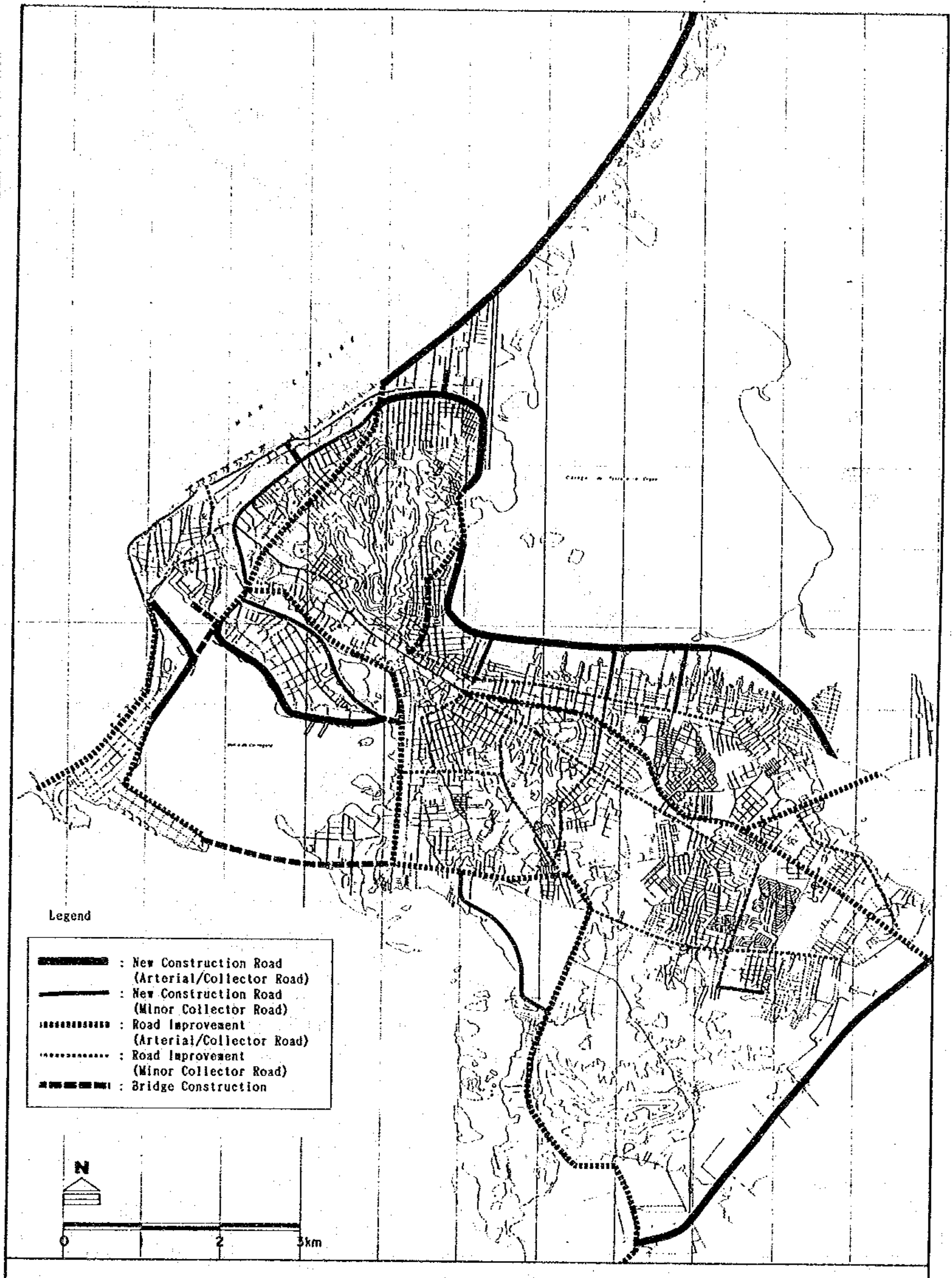


Figure 9.4-1(1) The Road Masterplan in 2010 (Urban Area)

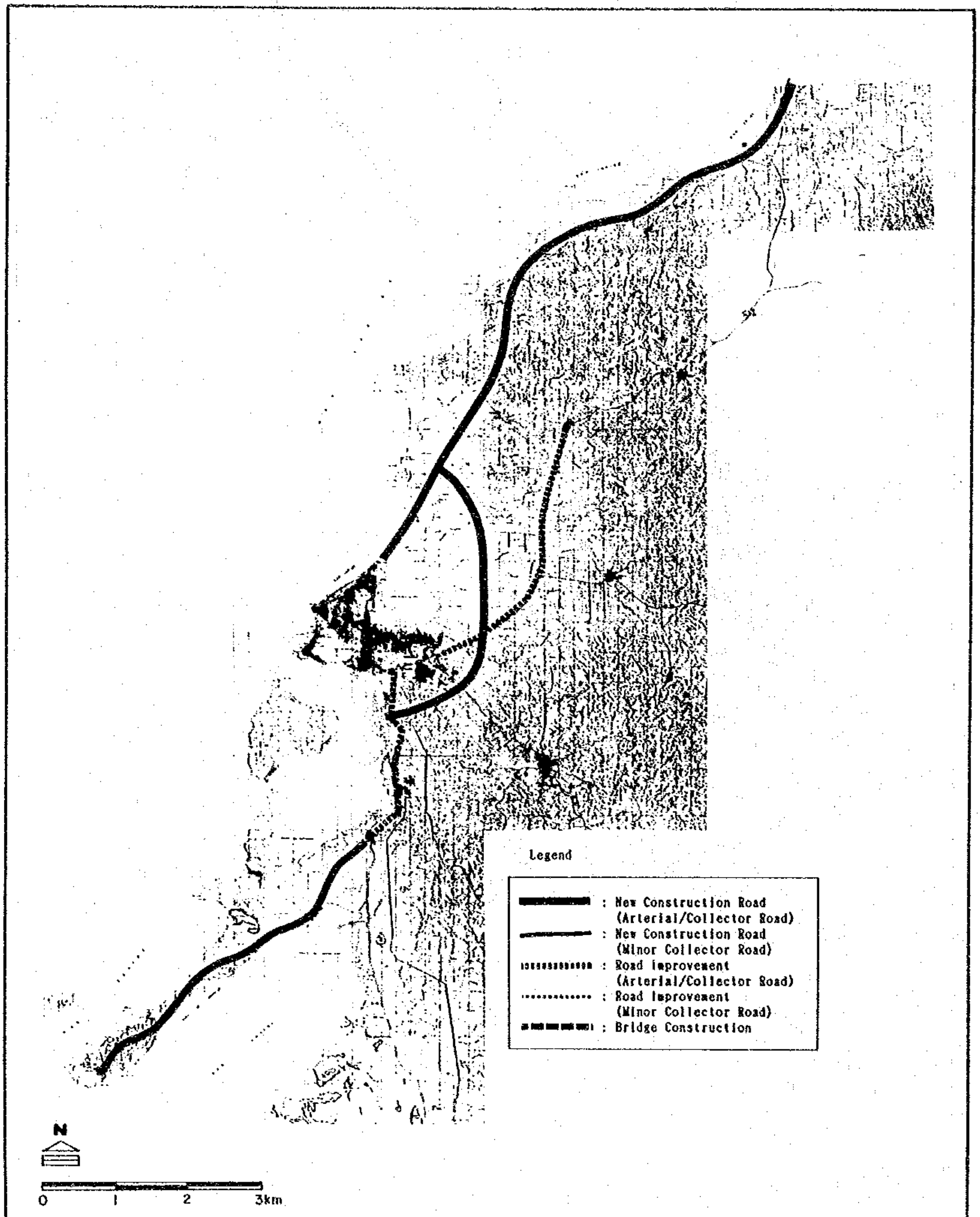


Figure 9.4-1(2) The Road Masterplan in 2010 (Sub-Urban Area)

603. Inside the urban area, almost all the projects were selected in the masterplan except a few projects listed below.

- C- 9: Cienaga de la Virgen Road
  (to be planned with provisional 2 lanes in the Masterplan)
- C-17: Ternera-Ladrillera Road
- C-18: Campestre-Anillo Vial Road
  (to be planned only some segments in the Master-plan)

Table 9.4-1 Masterplan Project List in 2010

Table Master Plan Projects in 2010

Items	Length (km)	2 Lanes	4 Lanes	6 Lanes
New Construction Roads				
- Arterial/Collector Roads	111.30	37.89	65.99	7.42
- Minor Collector Roads	11.49	8.38	3.11	0.00
Sub-Total	122.79	46.27	69.10	7.42
Road Improvement				
- Arterial/Collector Roads	59.61	0.00	40.10	19.51
- Minor Collector Roads	22.26	16.78	5.48	0.00
Sub-Total	81.87	16.78	45.58	19.51
Bridge Construction	5.99	0.84	5.15	0.00
Total Length	210.65	63.89	119.83	26.93

Table 9.4-2 New Construction Roads in the Masterplan

New Construction/ Arterial and Collector Roads

Pr.No.	Name	Length(km)	Remarks
C-1	Anillo Vial Road (Aeropuerto-Bocacanoa)	22.32	4/6 lanes/under constr.
C-2	Carretera del Mar Road (Bocacanoa-Palmarito)	23.78	4 lanes
C-3	Anillo Vial-Bocachica-Carretera del Mar Road	21.34	4 lanes
C-4	Trans-Baru Road	25.10	2/4 lanes
C-5	Baru-Tierra Bomba Road		
C-6	Nao-Ararca Road		
C-7	Navy Base Road	1.50	4 lanes
C-8	Juan Angola Road	2.68	2/4 lanes (Provisional 2 Lanes)
C-9	Cienaga de la Virgen Road	5.92	4 lanes (Provisional 2 Lanes)
C-10	Avenida Miramar Road (Pasteliollo-Bazurto)	2.67	4 lanes
C-12	Canteras Road (Puerto Bombero-Turbaco)	2.39	2 lanes
C-13	Camino a Turbana Road	3.60	2 lanes
	Sub-Total	111.3	

New Construction/ Minor Collector Roads

Pr.No.	Name	Length(km)	Remarks
C-11	Ceballos Road	2.19	4 lanes
C-14	Boston Road (Carrera 44)	0.53	2 lanes
C-15	Carrera 51 (Rafael Nunez)	0.58	2 lanes
C-16	Carrera 59 (Olaya Herrera)	0.89	2 lanes
C-17	Ternera-Ladrillera Road		
C-18	Campestre-Anillo Vial Road	1.55	2 lanes
C-19	5th Av. Manga	2.25	2 lanes
C-20	Chambacu Road	3.5	2 lanes
	Sub-Total	11.49	

Table 9.4-3 Bridge Construction in the Masterplan

Bridge Construction

Pr.No.	Name	Length(km)	Remarks
Br-1	San Lorenzo Bridge	0.20	2 lanes including approach
Br-2	Bazurto 2 Bridge	0.32	2 lanes including approach
Br-3	Manzanillo Bridge	2.70	4 lanes including approach
Br-4	Pasacaballo Bridge	1.05	4 lanes including approach in Project No. C-4
Br-5	Escollera Bridge		
Br-6	Bocachica Bridge		
Br-7	Cartagena Bay Bridge		
Br-8	Las Animas Bridge	0.60	4 lanes including approach
Br-9	Las Palmas Bridge	0.21	4 lanes including approach in Project No. I-15
Br-10	Marbella Bridge	0.32	2 lanes including approach
Br-11	Canapote Bridge	0.10	4 lanes including approach
Br-12	Crespo Bridge	0.10	4 lanes including approach
Br-13	Heredia Bridge	0.39	4 lanes including approach
	Total	5.99	

Table 9.4-4 Road Improvement Projects in the Masterplan

Improvement / Arterial and Collector Roads

Pr.No.	Name	Length(km)	Remarks
I-1	Bayunca-P.Canoas Road		
I-2	Ladrillera-Bayunca Road	18.26	From 2 to 4 lanes
I-3	Carrera 1 (Bocagrande)	2.64	From 2 to 4 lanes and 4 to 6 lanes
I-4	Calle 6 (C/Grand)	2.13	From 2 to 4 lanes
I-5	Carrera 30 (San Francisco-Quinta)	2.05	From 2 to 4 lanes
I-6	Avenida Jacobo del Valle	2.88	From 2 to 4 lanes
I-7	Diagonal 20/ Bosque	1.80	From 2 to 4 lanes
I-8	Transversal 54/ Bosque	2.29	From 2 to 4 lanes and 4 to 6 lanes
I-9	Calle 30 (Media Luna)	0.46	From 2 to 4 lanes
I-10	Calle 30 (Piede la Popa)	0.59	From 2 to 4 lanes
I-11	Av. Pedro de Heredia	4.26	From 4 to 6 lanes
I-12	Amplicacion Troncal Sta.Lucia-Temera	3.66	From 2 to 4 lanes
I-13	Transversal 54 (Amparo-Ladrillera)	1.90	From 2 to 4 lanes
I-14	Diagonal 30 (Coballo-Mamonal)	13.42	From 2 to 6 lanes
I-15	Carrera 17	3.27	From 2 to 4 lanes
	Sub-Total	59.61	

Improvement/ Minor Collector Roads

Pr.No.	Name	Length(km)	Remarks
I-16	Avenida Pedro Romero	4.21	From 2 to 4 lanes
I-17	Av. El Consulado/Piedra de Bolivar-Hos	3.85	2 lanes, pavement
I-18	Calle de Matadero	0.65	From 2 to 4 lanes
I-19	Transversal 45 (Juan 23)	1.25	2 lanes, pavement
I-20	Carrera 46 (Coballo-Espana)	2.32	2 lanes, pavement
I-21	Carrera 51 (Nuevo Bosque-Costa Linda)	2.13	2 lanes, pavement
I-22	Calle 41 (Av.Santander-India Catalina)	0.62	From 2 to 4 lanes
I-23	Antigua via Ternera	2.16	2 lanes, pavement
I-24	Carrera 71 (El Socorro-Biffi)	1.69	2 lanes, pavement
I-25	Calle 15 (Santa Clara-San Fernando)	3.38	2 lanes, pavement
	Sub-Total	22.26	

9.4.2 Road Masterplan Alternatives

604. The five (5) alternatives of the road masterplan were prepared from the base case masterplan (Case-1) based on the combination of the following projects.

1) Br-3: Manzanillo Bridge
2) Br-8: Las Animas Bridge
3) I-9 and 10: Calle 30 (widening 2 to 4 lanes)

605. These projects influence traffic movement on the heaviest traffic corridor in east/west direction. According to the traffic assignment on the base case masterplan, traffic movement to Centro will divert from Pedro de Heredia to Manga or Bocagrande by using both bridges. Therefore, it is indicated that traffic load on Pedro de Heredia is dependent on whether both bridge projects are executed, or not.

606. The five (5) alternatives are shown in Table 9.4-5.

Table 9.4-5 Alternative plans in the Masterplan

Case	Br-3	Br-8	I-9,10
1	O	O	O
2	O	O	X
3	O	X	X
4	O	X	O
5	X	O	O

Note: O : With Project
X : Without Project, in case of I-9,10 indicates the present condition

607. The efficiency for the projects of Calle 30: I-9 and 10, which widen the number of lanes from 2 lanes to 4 lanes was analyzed in the alternative case-2. Case-3 and Case-5 were prepared for analyzing the efficiency of whether Manzanillo bridge project: Br-3 which links between Manzanillo and Castillogrande is constructed or not. As for Case-4, the efficiency of the Las Animas Bridge project was also evaluated.

608. Table 9.4-6 shows assigned traffic volumes on the imaginary sections and Figures 9.4-2 to 9.4-6 show assigned traffic volume on the road network which is represented by "width in proportion to assigned traffic volume". The drawn line in black represents the situation that the volume-capacity ratio exceeds 1.5 or over, and the range from 1.0 to less than 1.5 is represented with a oblique line.

Table 9.4-6 Assigned Traffic Volume on the Imaginary Sections

Section-2: Bocagrande

Road Name	Case-1	Case-2	Case-3	Case-4	Case-5
1) I-3 :Av.Santander	61,145	61,057	88,442 *	88,634 *	65,072
2) Br-8:Las Animas Birdge	36,146	36,149	-	-	62,967 *
Sub-Total (Continental)	61,145	61,057	88,442 *	88,634 *	65,072
Sub-Total (Bridge)	36,146	36,149	-	-	62,967 *
Total	97,291	97,206	88,442	88,634	128,039
Capacity	120,000	120,000	72,000	72,000	120,000
Volume-Capacity Ratio	0.81	0.81	1.23	1.23	1.07

Note : * the volume capacity ratio exceeds 1.0

Section-3(1): Laguna de Chambacu-San Lazaro

Road Name	Case-1	Case-2	Case-3	Case-4	Case-5
1) I-3 :Av.Santander	41,370	41,292	41,129	40,269	41,065
2) I-9 :Calle 30 (Media Luna)	44,858	42,639	53,182 *	54,277 *	47,013
3) I-10:Calle 30 (Popa)	48,756 *	45,815	55,590 *	60,275 *	55,638 *
4) Br-8:Las Animas Birdge	36,146	36,149	-	-	62,967 *
5) Calle 25	20,652	20,652	22,530	22,395	19,096
6) Calle 24	16,704	17,826	22,772	20,241	11,048
Sub-Total (Continental)	172,340	168,224	195,203	197,457	173,860
Sub-Total (Bridge)	36,146	36,149	-	-	62,967 *
Total	208,486	204,373	195,203	197,457	236,827
Capacity	264,000	264,000	216,000	216,000	264,000
Volume-Capacity Ratio	0.79	0.77	0.90	0.91	0.90

Note : * the volume capacity ratio exceeds 1.0

Section-3(2): Manga-La Quinta

Road Name	Case-1	Case-2	Case-3	Case-4	Case-5
1) Av. Pedro de Heredia	81,404 *	76,365 *	78,511 *	75,982 *	79,910 *
2) I-6 :Av.Jacobo del Valle	44,370	46,336	48,186 *	46,969	59,104 *
3) C-19:5th Av.Manga	18,188	20,108	18,955	21,194	21,701
4) C-10:Av.Miramar Road	22,200	21,955	12,598	12,404	33,024
5) Br-3:Manzanillo Bridge	30,748	30,833	39,597	39,405	-
Sub-Total (Continental)	166,162	164,764	158,250	156,549	193,739 *
Sub-Total (Bridge)	30,748	30,833	39,597	39,405	-
Total	196,910	195,597	197,847	195,954	193,739
Capacity	240000	240000	240000	240000	192000
Volume-Capacity Ratio	0.82	0.81	0.82	0.82	1.01

Note : * the volume capacity ratio exceeds 1.0

609. Figure 9.4-7 shows the schematic traffic movements summarized in Figures 9.4-2 to 9.4-6 where the values in Figure 9.4-7 indicate different traffic volume from the base case. In case that only the Manzanillo Bridge project (Br-3) is executed, the major traffic movement changes. Approximately 30,000 pcu/day are diverted from the corridor in continental area into the bridge. When the Las Animas Bridge is not implemented during the construction of the Manzanillo Bridge, approximately 27,000 pcu/day are also diverted and about 9,000 pcu/day are added on the Manzanillo Bridge. As for the widening on Calle 30 (I-9 and 10), traffic volume on the corridor falls to only 4,000 pcu/day and the diverted traffic into the bridge is very small.

610. The Manzanillo Bridge project will make a great impact on traffic movement against the heavy traffic corridor. The Las Animas Bridge also alleviates the traffic load on the corridor. Table 9.4-7 shows the volume capacity ratio on the three sections: Bocagrande, Laguna de Chambacu-San Lazaro, and Manga-La Quinta. As seen, in case of without the Manzanillo Bridge project, the volume capacity ratio on the sections of the Bocagrande and the Manga exceed 1.0. When the Las Animas Bridge is not constructed, the figure on bocagrande section is over 1.0 and on Laguna is close to 1.0. Anyhow, those bridge projects are needed to alleviate the traffic congestion in future on the corridor.

Table 9.4-7 The Volume Capacity Ratio by Sections

Case No.	Bocagrande Section-2	Laguna -3(1)	Manga -3(2)	Without Projects
Case-1	0.81	0.79	0.82	
Case-2	0.81	0.77	0.81	I-9,10
Case-3	1.23	0.90	0.82	Br-8, I-9,10
Case-4	1.23	0.91	0.82	Br-8
Case-5	1.07	0.90	1.01	Br-3

9.4.3 Evaluation of Alternatives

611. In order to evaluate the alternatives from an economic point of view, the cost-benefit analysis was conducted by the alternatives. Two benefit items were estimated, that is, savings in vehicle operating cost (VOC) and in passengers' travel time cost (TTC). Benefit of a project is measured through so-called "with" and "without" comparison. Total VOC and TTC of each alternative case were caluculated and the difference of those of "without" case is estimated as project benefit. Ratio of B/C and