CHAPTER 11

TRAFFIC DEMAND FORECAST

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Traffic forecast constitutes the basis for a transport plan by illustrating the traffic demand. This chapter describes the procedure and outcome of the traffic forecast.

11.1 FORECAST PROCEDURE

The procedure applied to forecast the future traffic demand is based on the conventional four-step sequential model incorporated with mode choice by disaggregate model. The procedure is divided into three main phases. The main tasks under each phase are shown in Table 11.1-1 that includes the detailed components as well as methods and models applied for each parameter under these tasks. During all the steps of traffic demand analysis and forecast, and for traffic assignment procedures on the present and future road networks, the JICA STRADA (System for Traffic Demand Analysis) model is applied. The applied zoning system of the Study Area is shown in Appendix 11.1 for both the urban and suburban areas separately.

Table 11.1-1 Components of Traffic Demand Forecast Procedure

◊	Tasks	Parameter	Methods
Pre-Analysis Phase	Socio-Economic Framework	- Residential Population - Employment Scale - Type of Land Use - Area of Floor Space	- Base Units Model w/ Cross-Classification Analysis
	Trip Production	- Gender & Age - Household Income - Vehicle Ownership - (Driving License)	- Linear Function Model w/ Least Squares Regression
Technical Analysis Phase	Trip Generation & Attraction	- Trip Purpose - Trip Mode	- Log-Linear Function Model w/ Least Squares Regression
	Trip Distribution	- Trip Generation - Trip Attraction - Distance & Area	- Gravity Model (Basic / Voorhees / BPR)
	Modal Split / Mode Choice	- Travel Time - Travel Cost - Vehicle Ownership - Household Income	- Aggregate Model (Exponential / Power / Growth Curve)
			- Disaggregate Model (Multinomial Logit Model) w/ Maximum Likelihood Estimation
	Traffic Assignment	- Link & Node Data - Road Network Plan - Development Plan	- Incremental Assignment Model w/ QV Formula
Post-Analysis Phase	Evaluation of Alternatives, Feedback, and Comprehensive Forecast	(Quantity Index) - Traffic Volume - Service Frequency - Service Capacity (Quality Index) - Travel Time - Travel Cost (Other Index) - GDP & Income Level - Vehicle Ownership	- Elasticity Analysis
			- Economic Evaluation Net Present Value Method Benefit/Cost Ratio Method
			- Non-Economic Evaluation Goal Achievement Method Cost Effectiveness Method

11.2 TRIP PRODUCTION

The results of the household interview (person trip survey) and additional owner-driver interview indicate that the gross trip production ratio (number of trips per person) per day for inhabitants over 5 years old in the Study Area is around 2.35. Furthermore, total trip production within the Study Area is estimated by applying the trip production rates for each of the different types of modes times modal share and total number of population. After aggregation of the above-mentioned data (considering the number of cars owned by government, diplomatic and/or international aid organizations as well as their activities), the present total internal trip production has been estimated to be in the order of 3.24 million trips. External trip and internal cargo trip productions and their production ratios are summarized in Table 11.2-1.

Table 11.2-1 Trip Production Ratio & Total Trip Production

Category	Mode	Ratio	Share	Based Figure	Rectifier	Total
Internal Trip Production*1	ALL	2.35	1.00	Total Number of Inhabitants (1.15 million)	1.20*2	3.24 million
	PLV	2.98	0.08			
	PMC	2.59	0.51			
	CMC	2.13	0.14			
	CYC	1.85	0.02			
	WLK	1.99	0.25			
External Trip Production	ALL	N/A	1.00	(Total Number of Entering and/or Exiting Vehicles) x (Average Occupancy) = (85 thousand x 4.70)	1.00	0.40 million
Internal Cargo Trip Production*3	CLV & CHV	1.15	1.00	Total Number of Cargo Vehicles Operating within the Study Area (20 thousand)	1.00	0.023 million

Note: Mode / PLV: Private Light Vehicle, PMC: Private Motorcycle, CMC: Commercial Motorcycle, CYC: Cyclo/Bicycle, WLK: Walk, CHV: Commercial Heavy Vehicle, Ratio / Trip per Person (Gross)

11.3 TRIP GENERATION AND ATTRACTION MODELS

11.3.1 Trip Mode and Purpose Classifications

The trip mode and trip purpose through household interview (person trip survey) have been summarized to simplify the characteristics of individual trips. The trip modes and trip purposes are grouped into the seven (7) major modes and five (5) major purposes that are shown in Figure 11.3-1, as follows:

- Trip Mode: Private Light Vehicles [PLV], Private Motorcycles [PMC], Commercial Light Vehicles [CLV], Commercial Motorcycles [CMC], Commercial Heavy Vehicles [CHV], Cycles [CYC], and Walk [WLK]
- Trip Purpose: Home [HOME], Work [WORK], Business [BSNS], School [SCHL], and {Social [SOCL] / Shopping [SHOP] / Others [OTHR]} [PRVT]

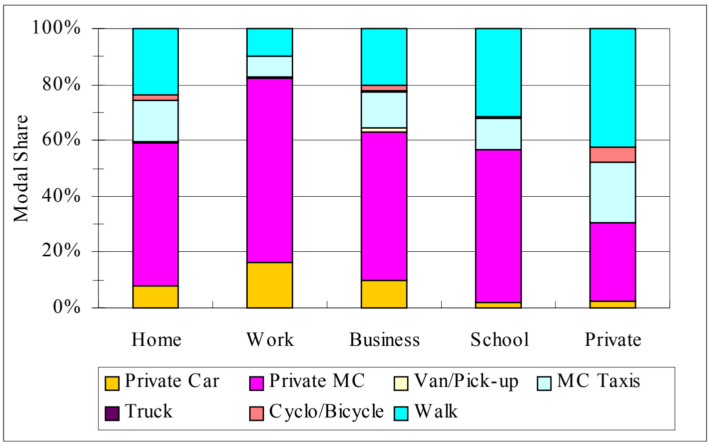


Figure 11.3-1 Modal Shares by Trip Purpose

*1 Trip production ratio of commercial vehicle users, such as taxi, mini-bus and/or long distance bus, has been discarded. Shares of those mode users were estimated less than one per cent of total internal trip demand and long distance trips by those modes have been counted by external trip production.
*2 1.20 is an adjustment factor to describe the difference between actual and analytical traffic volume in the Study Area.
*3 Cargo related trips from/to outside the Study Area have been counted by external trip production.

11.3.2 Trip Generation and Attraction Model

Multiple linear regression models that have several explanatory variables reflecting the present socio-economic framework have been formulated to characterize the present condition of the trip generation and attraction from/to each traffic zone. Furthermore, these models are applied to forecast the future trip generation and attraction for each zone by applying projected variables in the future socio-economic framework for the target years. The following are the formulated generation and attraction models with their corresponding correlation coefficient (r^2).

(1) Inter-zonal Generation Models by Trip Purpose

Home: [G-HOME *i*] = $0.4709 E^t i + 1.004 Si + 4482 U^d i + 22072 H^d i + 2670$ ($r^2 = 0.925$)

Work: [G-WORK*i*] = $0.4688 Pi + 10030 W^d i – 56$ ($r^2 = 0.924$)

Business: [G-BSNSi] = $0.08034 Pi + 275 U^d i + 1261 B^d i – 316$ ($r^2 = 0.911$)

School: [G-SCHL i] = $0.2480 Pi + 1369 U^d i – 286$ ($r^2 = 0.920$)

Social: [G-SOCL i] = $0.006139 Pi + 54 U^d i + 381 Sc^d i – 42$ ($r^2 = 0.870$)

Shopping: [G-SHOPi] = $0.2504 Pi + 2891 Sh^d i + 316$ ($r^2 = 0.963$)

Others: [G-OTHRi] = $0.06066 Pi + 3850 O^d i + 189$ ($r^2 = 0.832$)

(2) Inter-zonal Attraction Models by Trip Purpose

Home: [A-HOME*i*] = $1.123 Pi + 212.7$ ($r^2 = 0.986$)

Work: [A-WORK*i*] = $0.4191 E^c i + 0.2612.7 E^i i + 1.154 E^g i + 2585 U^d i + 22824 W^d i + 1066$ ($r^2 = 0.864$)

Business: [A-BSNS*i*] = $0.1957 E^c i + 2720 B^d i – 83$ ($r^2 = 0.872$)

School: [A-SCHL*i*] = $0.5249 Si + 893 U^d i + 462$ ($r^2 = 0.908$)

Social: [A-SOCL*i*] = $0.005912.7 P_i + 84 U^d i + 511 So^d i – 27$ ($r^2 = 0.870$)

Shopping: [A-SHOP*i*] = $0.1487 Pi + 2908 M^d i + 112.795 Sh^d i + 192$ ($r^2 = 0.889$)

Others: [A-OTHR*i*] = $0.05860 Pi + 3523 O^d i + 231$ ($r^2 = 0.807$)

Where, P*i* = Population of Zone *i*

E^t *i* = Total Employment of Zone *i*

E^c *i* = Commercial Employment of Zone *i*

E^i i = Industrial Employment of Zone i

E^g i = Governmental Employment of Zone i

S i = Total Number of Students in Zone i

U^d i = Urban Dummy for Zone i

M^d i = Market Dummy for Zone i, and

H^d i / W^d i / B^d i / Sc^d i / So^d i / Sh^d i / O^d i = Purpose-Specific Dummy for Zone i

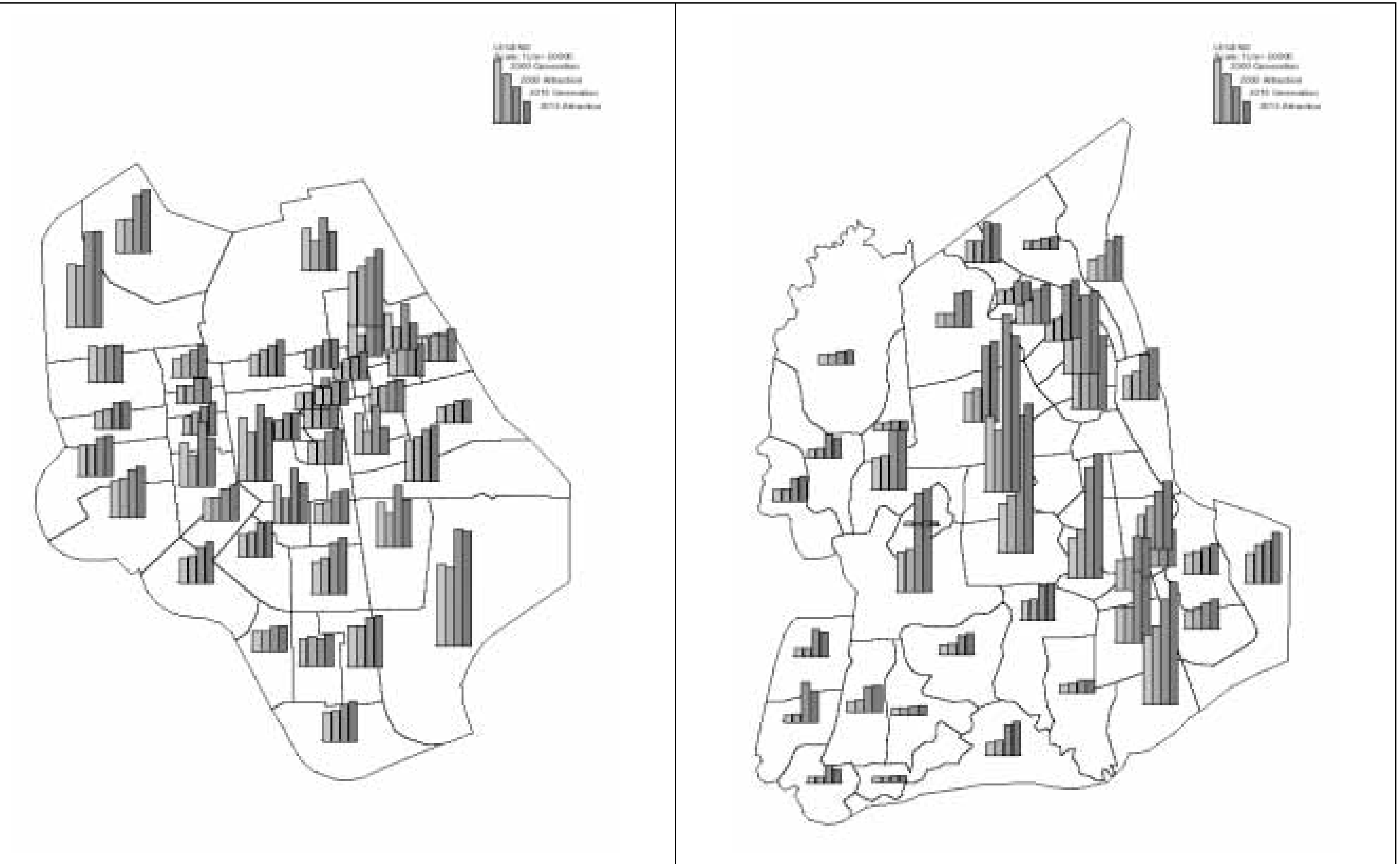
11.3.3 Trip Generation and Attraction

The zonal generated and attracted trips for each zone are presented graphically in Figure 11.3.2 for urban and suburban areas separately. The generated and attracted trips for the target years of 2005, 2010 and 2015 with the total growth rate in trips between the years 2000 and 2015 are presented in Table 11.3-1. Each growth rate given in this table is representing population growth in consideration with modal shift, such as motodop to private motorcycle and/or private motorcycle to private car. The main characteristics in the trip generation and attraction growth that can be concluded from this table are considered separately for each zone in the urban built-up area and the suburban areas.

Table 11.3-1 Summary of Trip Generation in Target Years

Trip Purpose	2000	2005	2010	2015	2015 / 2000
Home	1,629	1,981	2,343	2,657	1.63
Work	645	824	975	1,106	1.71
Business	97	110	136	175	1.80
School	387	404	483	644	1.66
Private	482	601	703	798	1.66
Total	3,240	3,920	4,640	5,380	1.66

Unit: 1,000 Person Trips / Day



- Urban Area - - Suburban Area -

Figure 11.3-2 Present and Future Zonal Generated and Attracted Trips

11.4 TRIP DISTRIBUTION MODELS

11.4.1 Inter Zonal Trip Distribution Model

The following basic gravity-type inter-zonal distribution model was developed in accordance with the analysis of the present OD pattern in the Study Area. In developing this model, the OD model builder of STRADA that applies different model types for inter-zonal trips, was utilized. The regression equation is:

$$Tij = k \bullet \frac{Gi^{\alpha} \bullet Aj^{\beta}}{dij^{-\gamma}}$$

Where, *Tij:* Inter-zonal Trips between Zone *i* and Zone *j*

Gi: Generated Trips from Zone *i*

Aj: Attracted Trips to Zone *j*

dij: Inter-zonal Impedance (Distance in kilometer) between Zone *i* and Zone *j*

k, α, β, *and* γ *:* Parameters, which are presented in Table 11.4-1.

Table 11.4-1 Parameters of Inter Zonal Trip Distribution Model

Parameters	k	α	β	γ	R^2
Study Area	0.007734	0.5402	0.5427	0.6003	0.6065

R^2: *Correlation Coefficient*

The zonal parameters are generally developed as a matrix synthesizing the future trip-interchange magnitude and overcoming imbalances in the trip-distribution, so that inter-changes ultimately balance by direction.

Figure 11.4-1 presents model sphere of traffic demand forecast and its covering area.

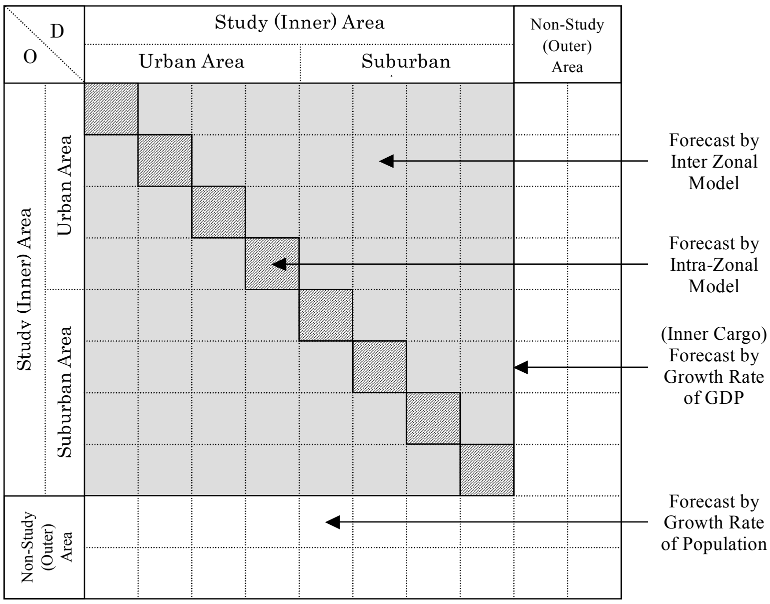


Figure 11.4-1 Model Sphere of Traffic Demand Forecast

11.4.2 Intra Zonal Trip Model

For intra-zonal trips, the following model was developed in accordance with the analysis of the present OD pattern in the Study Area as well as the total generated and attracted trips. In this model, the applied impedance factors are estimated based on the zonal areas. In addition, to avoid a so-called "multicolinearity" problem between two related explanatory variables in the standard equation of intra-zonal trip model, geometric mean of generated and attracted trips is applied as an explanatory variable for this model. The developed regression equation is:

$$Tii = k \cdot \left(\sqrt{Gi \cdot Ai}\right)^{\alpha} \cdot Zi^{\beta}$$

Where, *Tii:* Intra Zonal Trips within Zone *i*
Gi: Generated Trips from Zone *i*
Ai: Attracted Trips to Zone *i*
Zi: Intra-zonal Impedance (Area in hectare) of Zone *i*
k, α, and β: Parameters, which are presented in Table 11.4-2.

Table 11.4-2 Parameters of Intra-zonal Trip Model

Parameters	k	α	β	R^2
Urban Area	0.6154	0.6641	0.2417	0.2991
Suburban Area	-2.7802	1.0979	0.2059	0.8812
Study Area	-2.124	0.8785	0.4222	0.6063

R^2: *Correlation Coefficient*

The intra-zonal trips cannot be inputted as the data in the traffic assignment/forecast procedures since the computer model is designed to estimate only inter-zonal traffic. Intra-zonal traffic estimated here is used to consider trips mainly by walk.

11.5 MODAL SPLIT AND MODE CHOICE MODELS

11.5.1 Private Car & Motorcycle Share Model

Present private car and motorcycle shares were estimated from the result of household interview (person trip survey) and roadside traffic counts. According to the household interview, private car and motorcycle shares were related to the ownership rates and ownership rates themselves are closely related to the household income level as mentioned in the previous chapter. The results from the regression analysis between the modal share in the person trips and the household income level by using the logistic curves are as shown in Figure 11.5-1.

Figure 11.5-1 Private Car & Motorcycle Share vs. Income Level

The regression equation is:

$$Sh = \frac{k}{1 + me^{-at}}$$

Where, *Sh*: Private Car or Motorcycle Share in the Person Trips
t: Monthly Household Income in US$ (US$1.0 = Riel 3850)
k, m, and a: Parameters, which are presented in Table 11.5-1
e: Natural Exponential (= 2.71828)

Table 11.5-1 Parameters of Private Modal Share Model

Parameters	*k*	*m*	*a*	R^2
Private Car	0.127	35.34	0.053	0.8864
Motorcycle	0.706	4.401	0.032	0.6346

R^2: Correlation Coefficient

By applying this formula, the future modal shares are projected as shown in Table 11.5-2. The GDP per Capita as well as the average household income are forecast to increase twofold over the master plan period of 15 years. Consequently, the private mode share is expected to increase from about 60% to more than 80% in total. The private car share will increase from 8.3% to 12.6% while the private motorcycle share will increase from 52.2% to 68.6%.

As a consequence, the share of public (para-transit) modes are expected to substantially decrease from about 40% at present to less than 20% in the year 2015. Given the current high dependence on the motodop and other limited-capacity modes, there exists a potential for a large increase in the private mode share as household income increases, resulting in more traffic congestion. This potential can be reduced with the promotion of more efficient public transport modes such as the bus system.

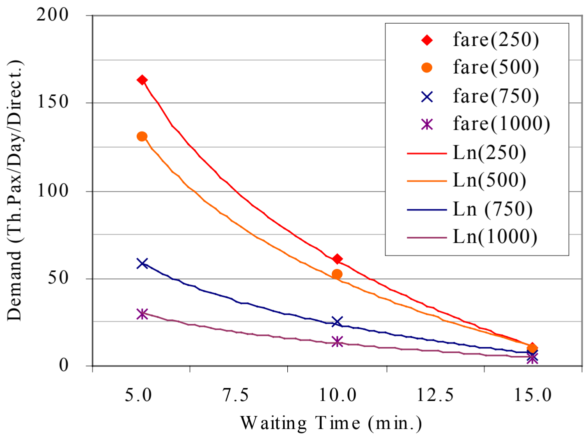
Table 11.5-2 Modal Share Forecast

Year	2000	2005	2010	2015
GDP per Capita (US$)	215	267	350	447
Average Household Income (US$)	79	98	129	164
Private Car Share	0.083	0.103	0.121	0.126
Private Motorcycle Share	0.522	0.583	0.650	0.686
Private Mode Share Total	0.605	0.686	0.771	0.811

Data Source: GDP per Capita was projected by CDRI
Average Household Income & Modal Shares are estimated by JICA Study Team

11.5.2 Public Transport Share Model

A public transport share model was formulated with reference to the results of the opinion survey carried out with the household interview (person trip survey). According to the opinion survey, not only motorcycle taxi (motodop) users, but also some private car and/or private motorcycle users will be inclined to utilize the proposed public transport system, under the condition of appropriate fare and frequency of operation, and interval of stops are provided. However, due to the lack of a clear picture for the proposed public transport system and its operation routes or location of stops at the time of the opinion survey, the available data for regression analysis were only: affordable fare, acceptable waiting time and acceptable walking distance to the nearest stops. Figure 11.5-2 shows the correlation between waiting time, fare and public transport demand. The public transport demand estimated by the method described here is compared with that estimated by disaggregate model constructed using the data of the Public Experiment (see Appendix 20.2-4). The deterrence of the two estimates are within a insignificant range. Accordingly, the public transport demand shown in Figure 11.5-2 is adopted throughout the Study.



Note: Fare (250/500/750/1000): Demand Estimation Points
Ln (250/500/750/1000): Approximation Natural Log Curves

Figure 11.5-2 Public Transport Demand vs. Fare and Waiting Time

After applying regression analysis on the aggregated data of the opinion survey, the following formula has been developed to explain the relations between passenger demands of proposed public transport system and combinations of its proposed fare and waiting time. The regression equation is:

$$Sh = \frac{e^{\gamma}}{F^{\alpha} \cdot T^{\beta}} \text{ or } Ln(Sh) = \gamma - \alpha \cdot Ln(F) - \beta \cdot Ln(T)$$

Where, *Sh*: Public Transport System (Bus) Share within the Accessible Area
F: Bus Fare in Riel (US$1.0 = Riel 3850)
T: Waiting Time (Operation Interval) in minutes
e: Natural Exponential (= 2.71828)
$\alpha, \beta,$ *and* γ: Parameters, which are presented in Table 11.5-3

Table 11.5-3 Parameters of Bus Share Model

Parameters	α	β	γ	R^2
Public Transport	1.3283	2.1935	9.9914	0.8652

R^2: Correlation Coefficient

According to this analysis, public transport demand is a dependent variable of fare and waiting time (operation intervals). However, longer waiting time causes a much larger decrease of demand than a higher fare setting. Table 11.5-4 presents results of sensitivity analysis of public transport demand against various fare and waiting time combinations.

Table 11.5-4 *Demand vs. Fare & Waiting Time

Waiting Time / Fare in Riel	5.0 min.	7.5 min.	10.0 min.
250	0.418	0.172	0.091
500	0.166	0.068	0.036
750	0.097	0.040	0.021
1,000	0.066	0.027	0.014
1,250	0.049	0.020	0.011
1,500	0.039	0.016	0.008

* Note: Figures in the table shows public transport modal share of person-trip within the accessible area. Accessible area is assumed that both sides within the distance of 150m from the proposed public transport routes, under the condition of intervals of stops are around 300m.

11.6 FUTURE TRIP PATTERN

Based on the OD tables of trips, the desire line charts, which clarify the distribution of trips and the interaction between zones, are presented in Figure 11.6-1 for total trips in both urban and suburban areas for the years 2000 and 2015. The person-trip OD pattern for the years 2000 and 2015 is summarized in Table 11.6-1.

Table 11.6-1 Estimated Person Trip OD Patterns - 2000 & 2015 -

◊ Present [2000] (Unit: Thousand Person-trip / day)

O \ D		Urban Area				Suburban Area				Total	
		CM	DP	PM	TK	DK	MC	RK	KD	BZ	CZ
Urban	CM	255.2	50.4	33.4	46.6	8.6	59.9	18.2	5.6	477.8	
	DP	60.3	135.7	41.1	55.4	12.3	35.5	44.0	4.4	388.7	
	PM	42.7	41.8	109.5	71.2	5.4	11.9	15.2	0.8	298.3	
	TK	54.3	55.1	40.5	172.3	24.5	28.4	21.6	2.0	398.7	1,563.5
Suburban	DK	11.5	14.8	12.9	26.6	247.8	17.6	22.4	4.1	357.7	
	MC	57.9	28.6	11.0	19.2	14.9	328.1	15.3	17.3	492.4	
	RK	20.2	38.0	31.0	23.7	13.5	6.1	532.7	4.7	669.9	
	KD	7.1	3.9	3.0	2.2	9.2	11.5	3.6	117.1	157.8	1,677.8
Σ	BZ	509.2	368.3	282.4	417.2	336.2	499.0	673.0	156.0	3,241.4	
	CZ				1,577.1				1,664.2		

◊ Future [2015] (Unit: Thousand Person-trip / day)

O \ D		Urban Area				Suburban Area				Total	
		CM	DP	PM	TK	DK	MC	RK	KD	BZ	CZ
Urban	CM	464.0	82.0	53.8	80.1	17.5	99.4	29.5	9.2	835.6	
	DP	99.1	248.4	63.2	91.3	22.7	57.8	70.8	9.3	662.6	
	PM	54.4	63.3	156.0	96.3	11.9	22.9	26.3	2.2	433.4	
	TK	78.8	84.4	64.1	300.6	53.2	52.3	35.0	5.1	673.5	2,605.1
Suburban	DK	20.5	23.0	12.8	43.1	467.4	31.3	33.8	10.7	642.8	
	MC	83.4	40.6	17.6	30.6	28.2	549.3	23.8	40.8	814.2	
	RK	28.3	56.1	38.5	40.7	28.5	9.4	838.0	11.2	1,050.9	
	KD	6.6	4.7	1.7	3.1	6.1	17.1	4.3	225.1	268.6	2,776.5
Σ	BZ	835.2	602.7	407.8	685.9	635.4	839.4	1,061.5	313.6	5,381.5	
	CZ				2,531.6				2,849.9		

◊ Growth Index [2015/2000]

O \ D		Urban Area				Suburban Area				Total	
		CM	DP	PM	TK	DK	MC	RK	KD	BZ	CZ
Urban	CM	1.82	1.63	1.61	1.72	2.03	1.66	1.62	1.65	1.75	
	DP	1.65	1.83	1.54	1.65	1.85	1.63	1.61	2.10	1.70	
	PM	1.28	1.51	1.43	1.35	2.21	1.93	1.74	2.83	1.45	
	TK	1.45	1.53	1.58	1.74	2.18	1.84	1.62	2.50	1.69	1.67
Suburban	DK	1.78	1.55	1.00	1.62	1.89	1.77	1.51	2.62	1.80	
	MC	1.44	1.42	1.60	1.59	1.88	1.67	1.55	2.36	1.65	
	RK	1.40	1.48	1.24	1.72	2.11	1.53	1.57	2.39	1.57	
	KD	0.92	1.20	0.57	1.41	0.66	1.48	1.17	1.92	1.70	1.65
Σ	BZ	1.64	1.64	1.44	1.64	1.89	1.68	1.58	2.01	1.66	
	CZ				1.61				1.71		

Note: Urban Area / CM - Chamkar Mon, DP - Daun Penh, PM - Prampi Makara, TK - Tuol Kork
Suburban Area / DK – Dang Kao, MC - Mean Chey, RK - Russie Kaev, KD – Kandal
Zoning / BZ - B Zone (8 Districts / Urban 4 Zones & Suburban 4 Zones), CZ - C Zone (Urban & Suburban)

- Year 2000 -

- Year 2015 -

Figure 11.6-1(a) Desire Line Chart - Urban Area -

- Year 2000 -   - Year 2015 -

Figure 11.6-1(b) Desire Line Chart - Suburban Area -

11.7 TRAFFIC ASSIGNMENT

11.7.1 Traffic Assignment Model

(1) Present Network Model

Prior to the traffic assignment, a virtual road network covering the Study Area and adjacent areas has been formulated into the JICA-STRADA program file in accordance with the link and node information. This information has included factors such as road length, free flow speed, traffic capacity, one-way control, and/or prohibition of through pass on specific sections and/or modes as well as prohibition of left turn at specific intersections. These factors have been distributed along the virtual road network in accordance with the road inventory records, other related handbooks and/or manuals, and the proposed road network plan.

(2) Present Modal Share Pattern

According to the results of the person-trip survey and other traffic counts carried out in the Study Area, the modal shares of the present pattern, presented in Table 11.7-1, have been observed. Without certain countermeasures to be implemented by the authorities, such as introduction of Public Transit, Area Licensing, Road Pricing, or so-called Traffic Demand Management (TDM), this present pattern of modal share will continue, or the share of private cars will escalate in accordance with economic development after decades of instability. Within this context, further analysis was carried out under this assumption that "Present Pattern" is the base model to estimate corresponding future modal share. With this pattern, share of private car (PLV) will increase from 10.9% to 17.5 % from year 2000 to 2015, while that of private motorcycle (PMC) will decrease from 69.4% to 63.0% over the same period. Shares of the other modes in 2015; motodop (CMC), bus (BUS) and cycle/bicycle (CLV), remains the same as those of the present pattern.

The modal shares of "Pedal-cycles" (cyclo and bicycle) and "Walk" are assumed to remain the same as their present condition that covers almost one-forth of total trips. Therefore, those two shares will be discarded in further analysis. Furthermore, this "Present Pattern" will be considered as the same case as "Alternative-1" described in Part III, Chapter 12.

Table 11.7-1 Present and Future Modal Share (Present Pattern)

	PLV	PMC	CMC	BUS	CLV
Present (2000)	10.9	69.4	18.9	0.0	0.8
Future (2015)	17.5	63.0	18.7	0.0	0.8
Difference	+6.6	-6.4	-0.2	0.0	0.0

Unit: percentage in total, except pedal-cycle and walk

(3) Free Flow Speed

The free flow speed is largely determined in accordance with the design speed of each section of road. However other factors may affect this free flow speed. These factors include, number of lanes, width of lane and shoulder, presence of median, surface condition, side friction caused by on-street parking, roadside activities, side and/or overhead obstructions, as well as traffic volume itself and commercial vehicles and/or motorcycles ratios. To establish the free flow speed, the entire road network has been classified in accordance with the category of road specified in the road inventory, and then several patterns of free flow speed have been applied into each link of the road network, based on the result of travel speed survey and road inventory survey.

(4) Traffic Capacity

The basic traffic capacity per lane for a multiple lane, divided road is standardized at around 2,200~2,500 pcu/hr by the road design standards in most developed countries. However, the traffic capacity of a 2-lane 2-way undivided road is not double the basic capacity for one lane due to risk and/or chance of overtaking and the other various factors mentioned above. For the purposes of further analysis, the traffic capacities presented in Table 11/7-2 are adopted. These capacities very depending on road classification, number of lanes and free flow speed and have been established taking into account the present and/or proposed condition of the road network in the Study Area.

Table 11.7-2 Free Flow Speed and Traffic Capacity by Road Classifications

Road Classifications		Number of Lanes	Free Flow Speed (km/h)	Traffic Capacity (pcu/hr)
Urban	Arterial	4	50 (60)	4,800 (7,200) 3,600 (5,400)
		2	40 (50)	2,400 (3,600)
	Collector	2	30 (40)	1,800 (2,400)
	Local	2	20 (30)	1,200 (1,800)
Suburban	National Road	4	50 (60)	4,800 (7,200) 3,600 (5,400)
		2	40 (50)	2,400 (3,600)
	Collector	2	30 (40)	1,800 (2,400)
	Local	2	20 (30)	1,200 (1,800)

Note: Values in the parenthesis are applied into the link with good surface condition.
A one rank higher capacity is applied to links with one-way control or median.
Upper values shall be applied to links with wide shoulder (over 1.5m), and lower values shall be applied to links with narrow shoulder (under 1.5m) in 4-lane Urban Arterial and/or Suburban National Road

(5) Passenger Car Unit and Occupancy

The passenger car unit (pcu) equivalents and average occupancies as shown in Table 11.7-3 are applied to the traffic assignment model. These values were determined based on the results of a cordon line (as shown Table 4.3-2) survey, referring to the related handbooks and/or manuals.

Table 11.7-3 Passenger Car Units and Average Occupancies

Unit	Area	PLV	PMC	CLV	CMC	BUS	TRK	CYC
PCU's	Both	1.00	0.50	1.00	0.50	3.00	3.00	0.50
Occupancies	Urban	1.50	1.20	1.50	0.75	15.00	3.00	1.50
	Suburban	4.50	1.80	9.00	3.00	15.00	3.00	1.50

Note: Occupancies in Urban Area, and suburban area are estimated from the values based on the results of calibration from Screen Line Survey and weighted average of findings from Cordon Line Survey.

(6) Link Characteristics

The QV (Volume vs. Speed) relation as shown in Figure 11.7-1 is applied to the traffic assignment model (See Section 11.7-1 (3) and (4) for explanation of Free Flow Speed, Vmax, and Capacity, Q).

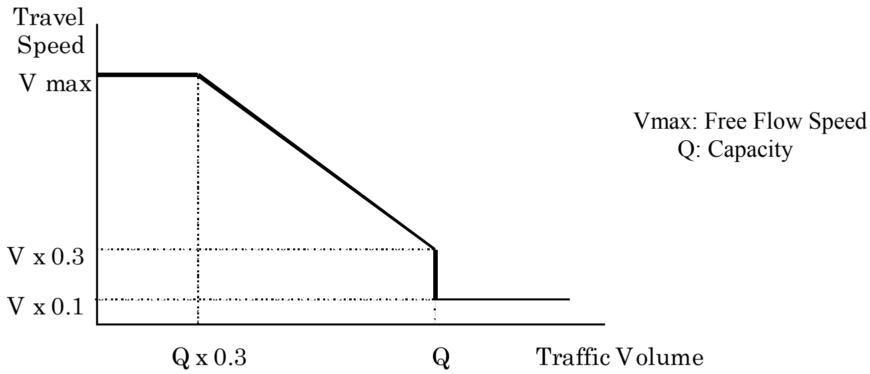


Figure 11.7-1 QV Relation in Traffic Assignment Program

11.7.2 Assignment Results

The results of the traffic assignment procedure show the traffic volumes on the different links of the road network for the present condition as well as for each of the target years of 2005, 2010 and 2015. Several runs were made for each case of the assignment to provide feedback information for future road network improvement schemes.

Figures 11.7-2 (a) and (b) show one of the evaluation indices, which is the average congestion ratio (Volume-Capacity Ratio: VCR), for the present as well as for each of the target years of 2005, 2010, and 2015. The ratio is estimated based on the assignment results for the road network of both urban and suburban areas in the "Do Nothing Case" in which the improvement projects of the Master Plan will not be implemented.

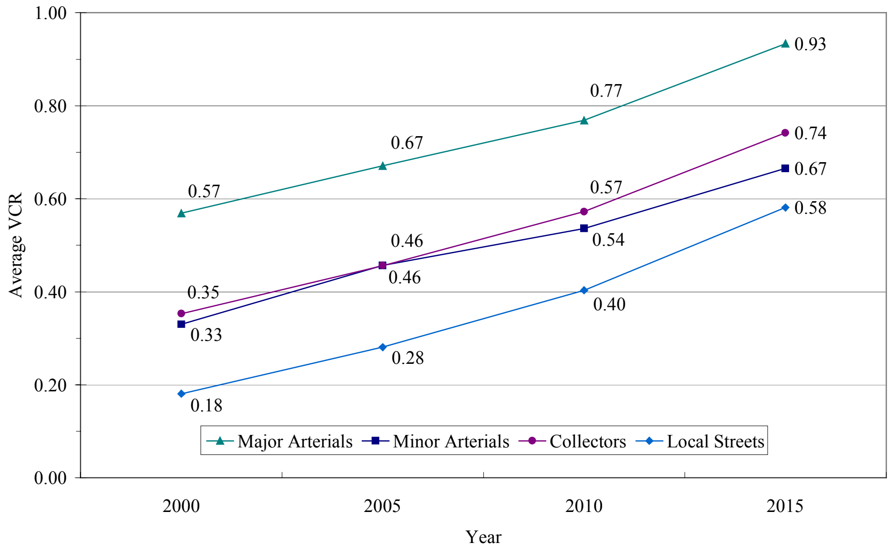


Figure 11.7-3 (a) Present and Future Average Volume -Capacity Ratio (Urban Area) - Do Nothing Case -

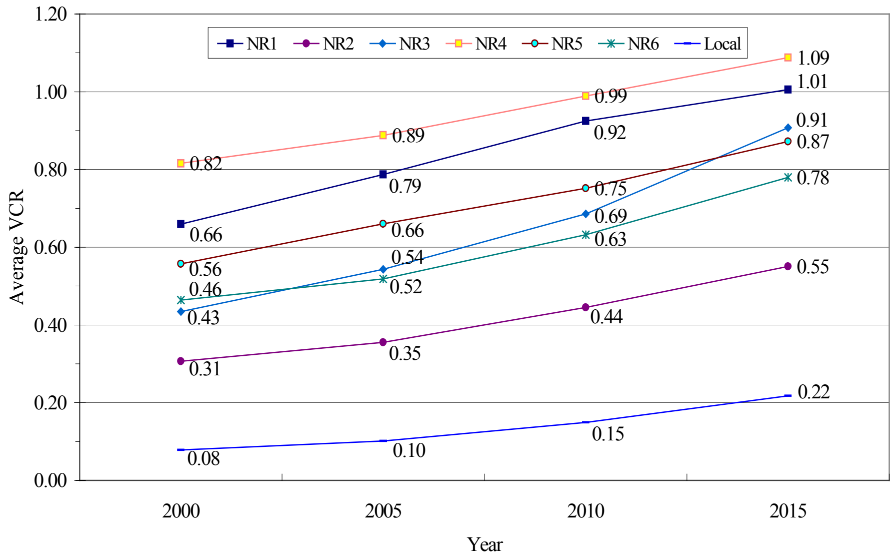


Figure 11.7-3 (b) Present and Future Average Volume -Capacity Ratio (Suburban Area) - Do Nothing Case -

According to the results of this "Do Nothing Case", the average VCR in 2015 will increase in the urban area to 1.64 times for "Major Arterials", and 3.22 times for "Local Streets", and in the suburban area, 1.33 times for "N.R. No.4", 2.09 times for "N.R. No.3"*, and 2.79 times for "Local Roads".

Figure 11.7-4 (a) and (b) shows the present and future traffic volumes on the road network of both urban and suburban areas separately in the "Do Nothing Case" in which no improvement projects from the master plan will be implemented.

According to this result of the traffic assignment for year 2015, several sections of road network may suffer from very heavy traffic congestion with VCR of over 1.50.

These sections are mainly at entries of the urbanized area on major radial arterials, such as N.R.1, 4, 5 and 6, or Veng Sreng Road in Mean Chey District, due to concentration of traffic between the urbanized area and suburban/rural area with incomplete road networks in the suburban area.

Other sections may suffer from heavy congestion in the suburban areas are Phnom Penh Highway (Toll Road), Tumpum Dike Road, Russie Kaev Bypass, and Cheung Aek Road.

In addition, the other sections in the urbanized area also suffer from heavy congestion with VCR of over 1.00.

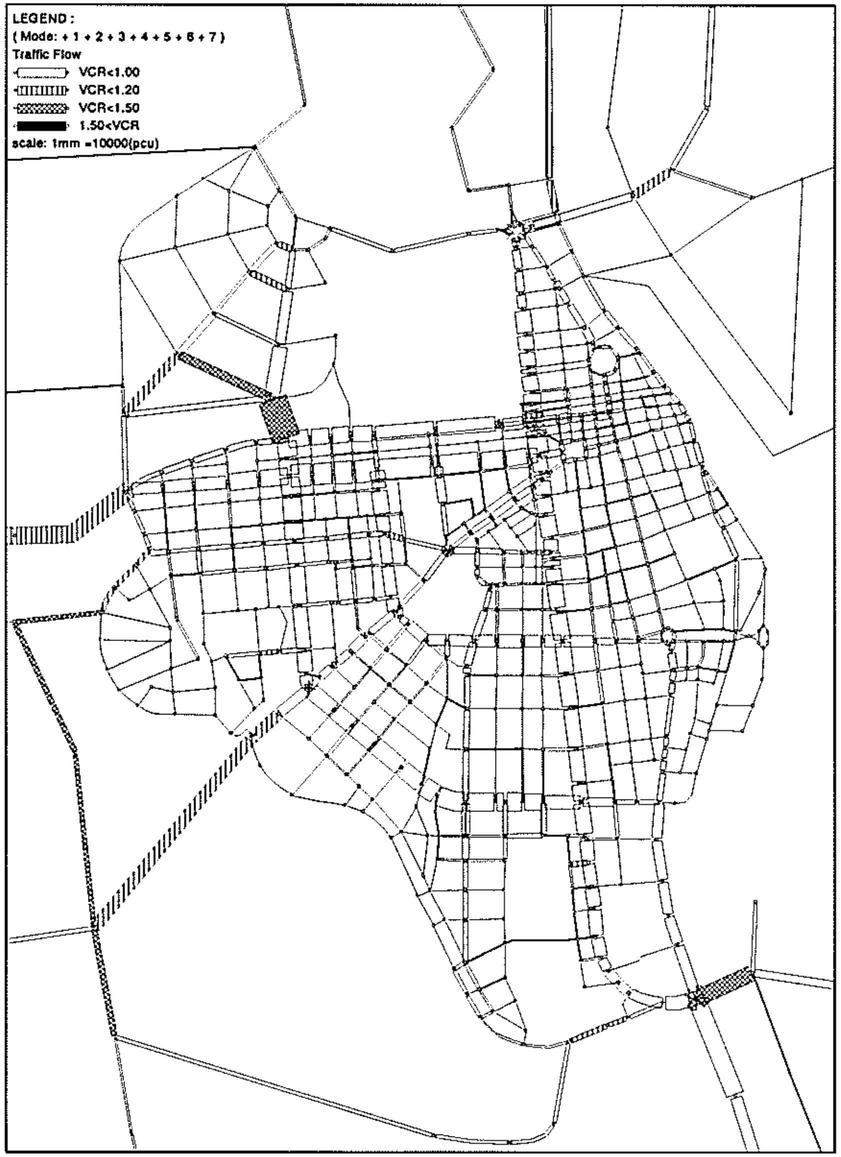
These sections are mainly on the major radial arterials, such as Norodom, Monivong, Monireth, Kampuchea Krom, and Russian Boulevards, or major circular arterials, such as Sihanouk, Mao Tse Toung, and its extension, Kim Il Sung Boulevards, and some minor arterials, such as Sisowath, and France Roads due to concentration of intra-city traffic on those relatively well maintained arterials.

On the other hand, collectors and local streets in the both urbanized and suburban areas seem to be not congested even in the future, except several areas with limited road network, such as some area in Toul Kouk, Mean Chey, Dang Kao, or Russie Kaev Districts.

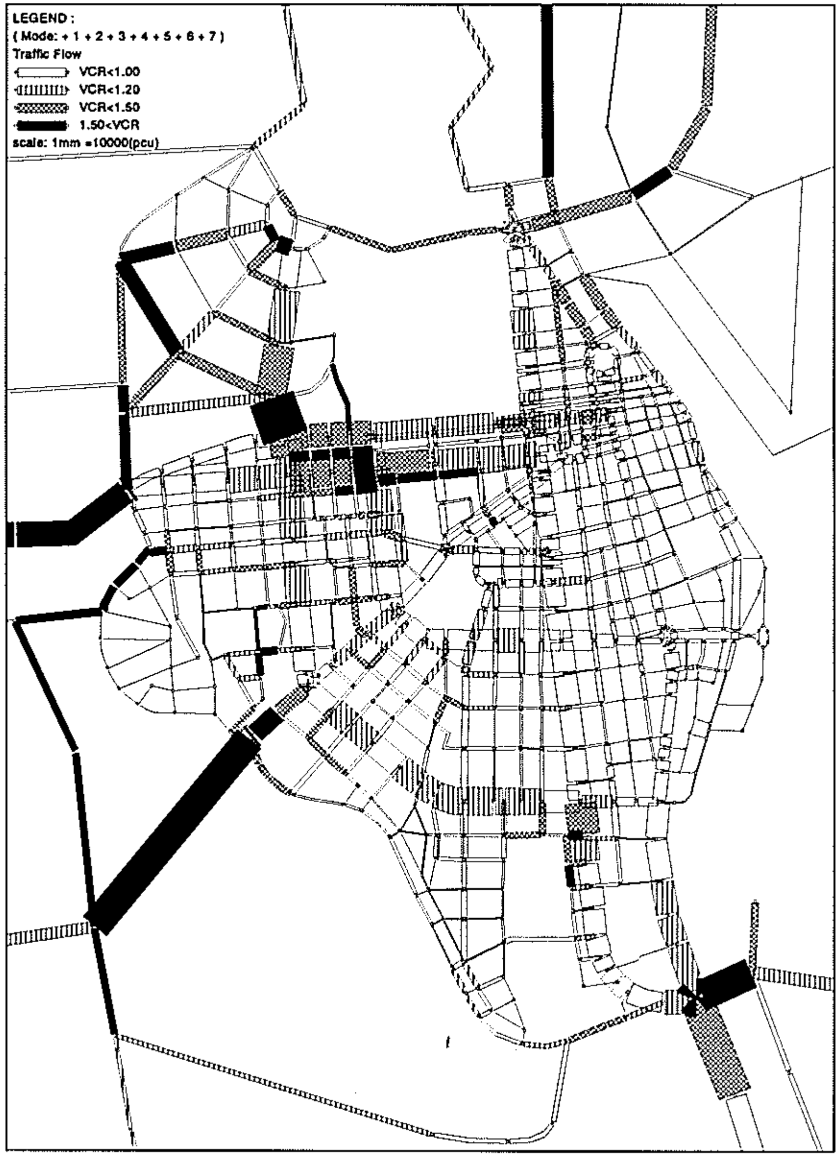
This is because the surface condition of these roads are assumed to be very poor and vehicle tend not to flow to these roads.

The above-mentioned sections of roads and/or related links will require some form of improvement, such as widening, bypassing, and/or reducing traffic volume, staged at appropriate times in the future to avoid possible traffic jams and/or other related issues caused by projected traffic flows.

* N.R. No.3 here is including Phnom Penh Highway (Toll Road) that is locating south side of Pochentong International Airport.

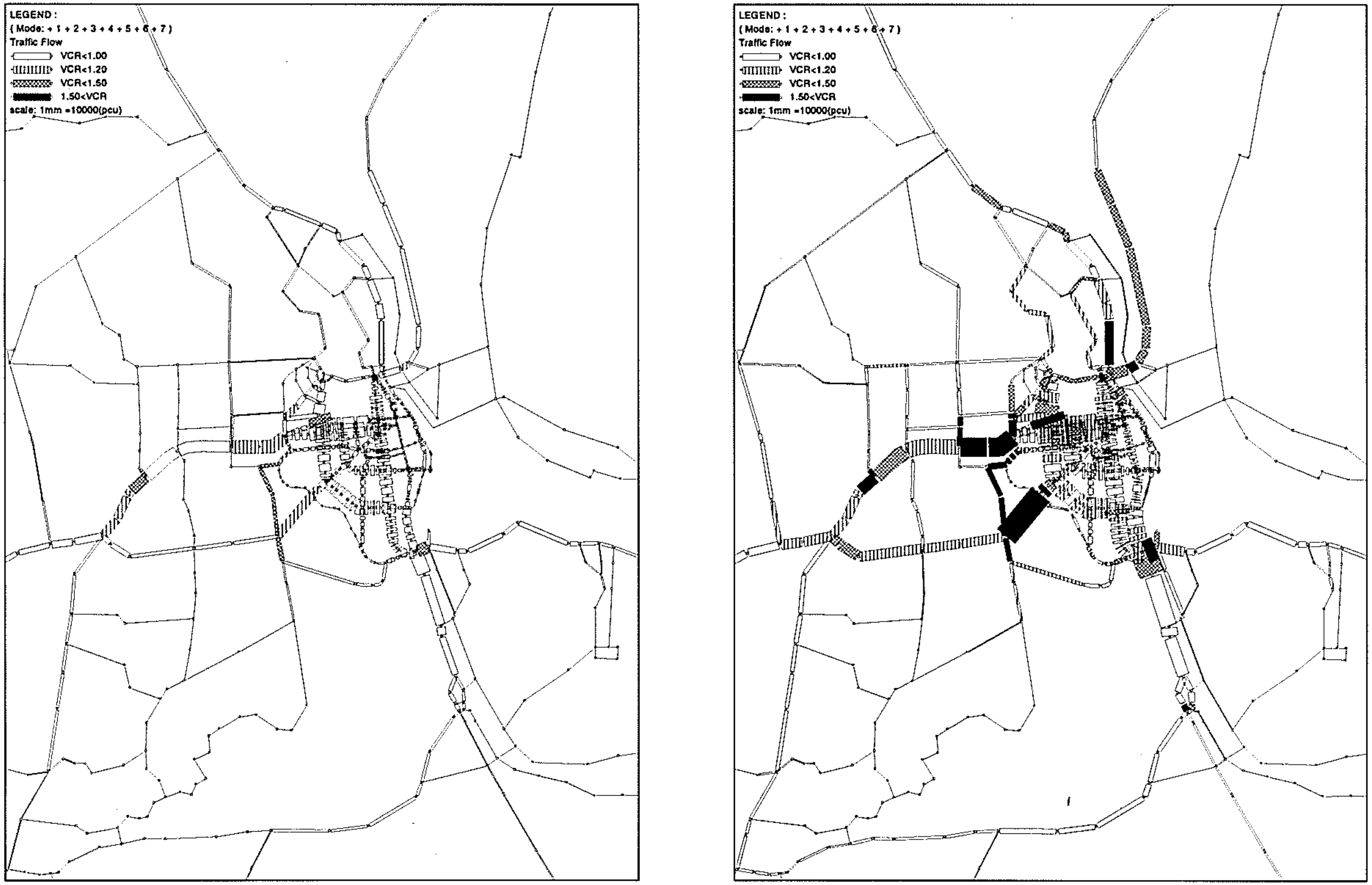


- Year 2000 -



- Year 2015 -

Figure 11.7-4 (a) Present and Future Traffic Volume - Urban Area - Do Nothing Case (1/2)



- Year 2000 -

- Year 2015 -

Figure 11.7-4 (b) Present and Future Traffic Volume - Suburban Area - Do Nothing Case (2/2)