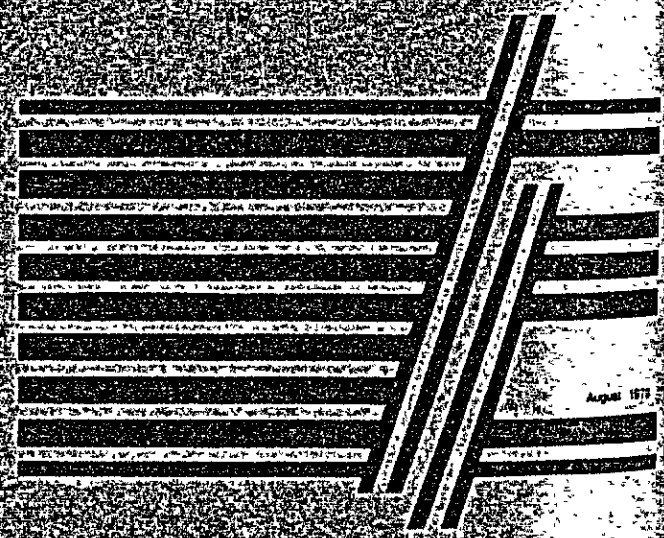


CHAPTER I

LAND USE

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Chapter 4 LANDUSE

4.1 Methodology

The two main objectives for the Landuse Study are:

- To project the future statistical and physical conditions in Greater Bangkok*¹ and its surrounding regions;

and

- To provide a statistical base for Chapter 5: TRANSPORTATION PLANNING AND FORECASTS OF FUTURE TRAFFIC DEMAND.

Notes: *1 In this study, Greater Bangkok indicates the region dealt with by 'Greater Bangkok Plan', DTCP, originally issued in 1960 and revised several times since then. The "Greater Bangkok Area" (GBA) consists of four administrative units or Changwats: Phra Nakhon, Thonburi, Nonthaburi and Samut Prakan.

To show the present and future commuting situations in the Traffic Study, which is one of the major study items of this project as a whole, the economically active population*² and workers at work places in each zone*³ are calculated separately for input data to the person-trips distribution later in the traffic study.

Notes: *2 The economically active population in a region is the portion of residential population who have jobs.

- *3 The number of workers at work places in a region is the number of workers who actually work there including those who live outside and commute.

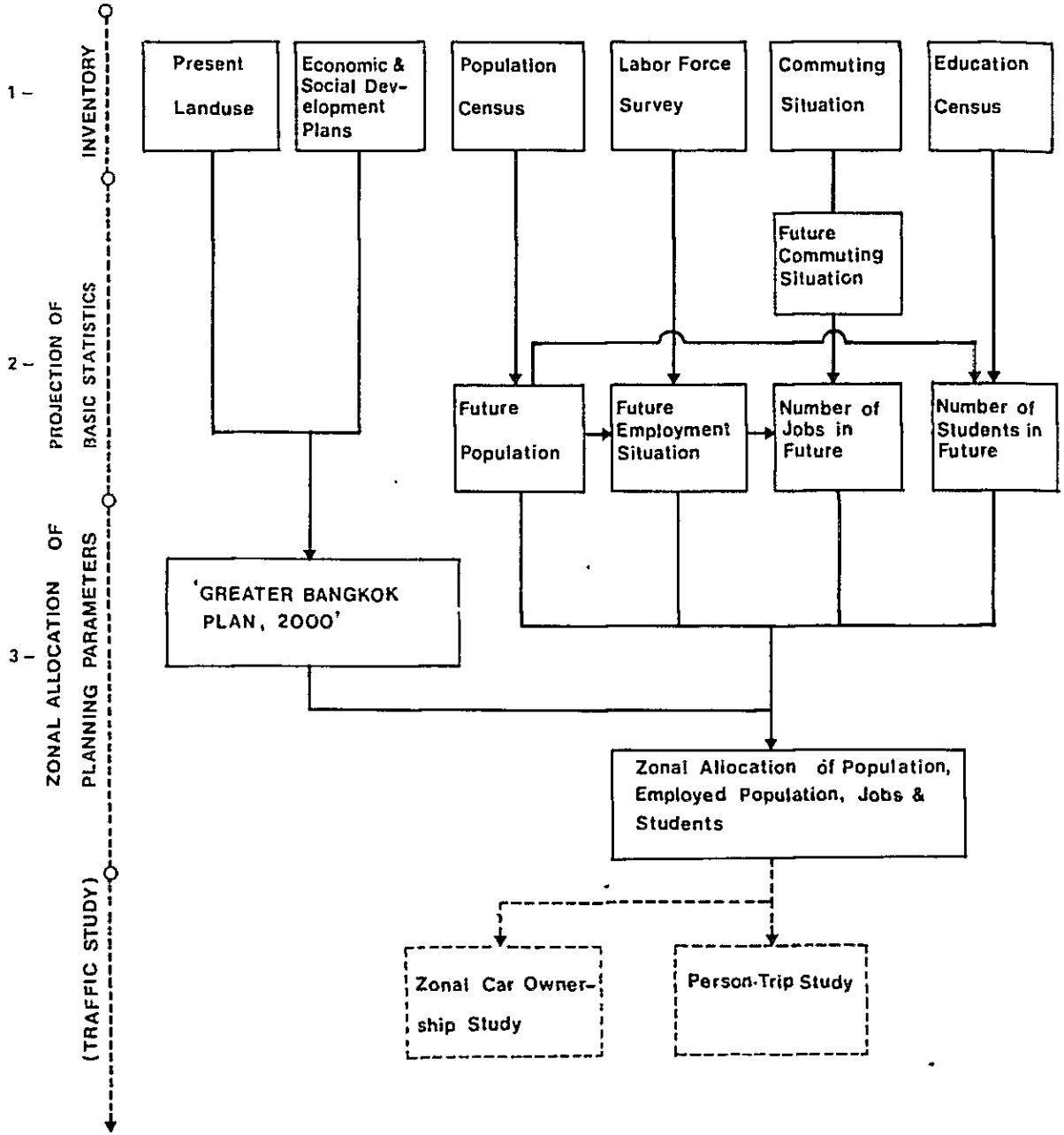
The Landuse Study is done in three steps as shown in Fig. 4-1, and they are:

- 1 - Inventory;
- 2 - Projection of Basic Statistics; and
- 3 - Zonal Allocation of Planning Parameters.

The past basic statistics such as the residential population, economically active population, commuting population and the number of traffic-relevant students are analyzed, and then projected into the future. The data from The Fourth Development Plan was particularly utilized in this study.

Although, the Landuse Study deals with the whole Central Region, zonal allocation of planning parameters is done only for the main study area, Greater Bangkok, using the basic statistics projected as regional controls. For the rest of the study area outside Greater Bangkok, only the residential population is distributed over zones. The commuting traffic volume, both of workers and students, is calculated by major directions based on the results of the traffic counting survey carried out by the Dept. of Highways at selected counting stations on the border of Greater Bangkok.

Fig. 4-1 METHODOLOGICAL FLOW CHART FOR LANDUSE STUDY



4.2 Statistical Framework

4.2.1 General

The whole Kingdom of Thailand is divided into four administrative regions. Greater Bangkok consists of four Changwats out of the twenty-seven Changwats forming the Central Region. The statistical framework for the future residential population*4, economically active population, workers at work places and traffic-relevant students is made for Greater Bangkok and the rest of the Central Region separately taking the commuting traffic volume between these two regions into considerations.

Notes: *4 For Greater Bangkok the population projection by 'Greater Bangkok Plan' is adopted without modification.

Table 4-1 AREA OF GREATER BANGKOK & CENTRAL REGION

(Unit: Ha)	
	Area
Greater Bangkok	316,600
Central Region	9,882,000
Total Thailand	54,237,300

Source: 'Statistical Year Book, Thailand, No. 31 1974-75', NSO.

4.2.2 Residential Population

Projection of residential population was done assuming future growth rates in each future five year period both for population increases by natural growth and migration.

A population projection for the whole Kingdom was found in 'Bulletin of Statistics', NSO, 1977. Since the population increase by migration for the whole Kingdom is very small, the growth rates in the above projection are considered to be from natural increases.

Table 4-2 POPULATION PROJECTION OF THAILAND

(Unit: 1,000 Persons)									
	1970	1975	1980	1985	1990	1995	2000	2005	2010
Population	36,370	41,869	47,686	53,851	60,310	66,951	73,614	80,126	86,154
Average Annual Growth Rates for 5 yrs. (%)	-	(2.9)	(2.6)	(2.5)	(2.3)	(2.1)	(1.9)	(1.7)	(1.5)

Source: 'Bulletin of Statistics', Vol. 25-26 No. 2, NSO, 1977.

Generally, natural growth rates are more consistent among different regions than growth rates by migration, but for the Central Region including Greater Bangkok, which is exceptionally urban in its character,

the above natural growth rates are not applicable.

In the Fourth Development Plan, the Government set the goal to reduce the national population growth rate from 2.5% to 2.1% during the period from 1977 to 1981. The future natural growth rate for Greater Bangkok is based on this figure.*5

Notes: *5 Chapter V, 1.2 Demographic Objectives and Policy Guidelines, the Fourth Development Plan.

A population projection for the Central Region up to 1981 is found in the Fourth Development Plan. After adjustment with the most recent data, the above projection was further extended into the future until 2000.

The portion of increase by migration for Greater Bangkok, the whole Central Region and the Central Region outside Greater Bangkok is calculated by subtracting the natural increase portion from the total population increase.

In the past, the migration flow to the Central Region has been primarily directed towards Greater Bangkok, even from the Central Region outside Greater Bangkok.

The population increase by migration into Greater Bangkok in future is assumed to become much more moderate because of social and economic development in the rural areas.*6

Notes: *6 In the Fourth Development Plan the following migration policies are outlined in the following sections:

'2.2.3 Intra-regional migration is to be supported more than inter-regional migration.'

'2.2.4 With respect to rural-urban migration, support should be given to the flow of migrants into the principal urban centers of each region, in line with the guidelines laid down for regional development.'

Fig. 4-2 RESIDENTIAL POPULATION PROJECTION

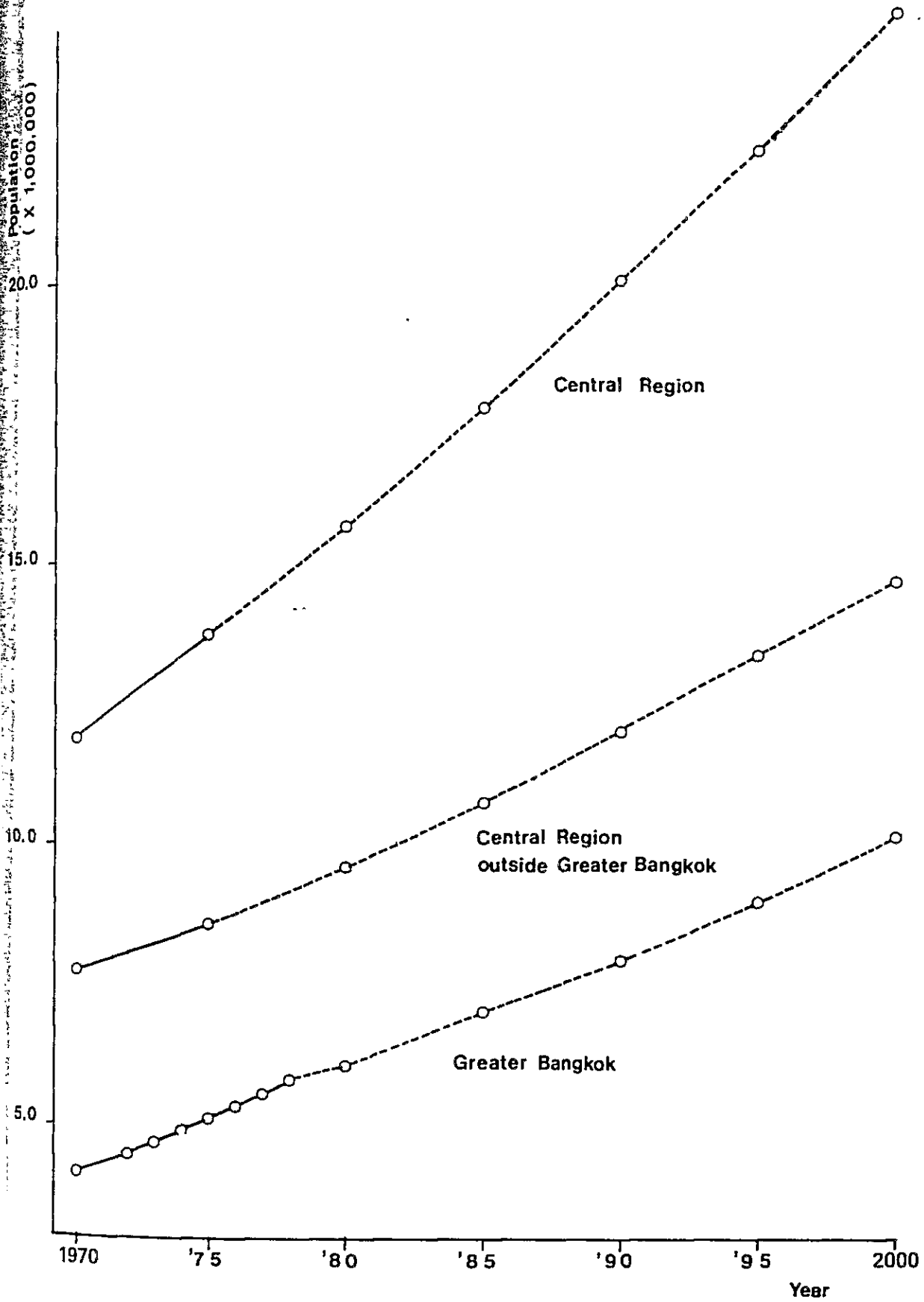


Fig. 4-3 PROJECTION OF MIGRATING POPULATION

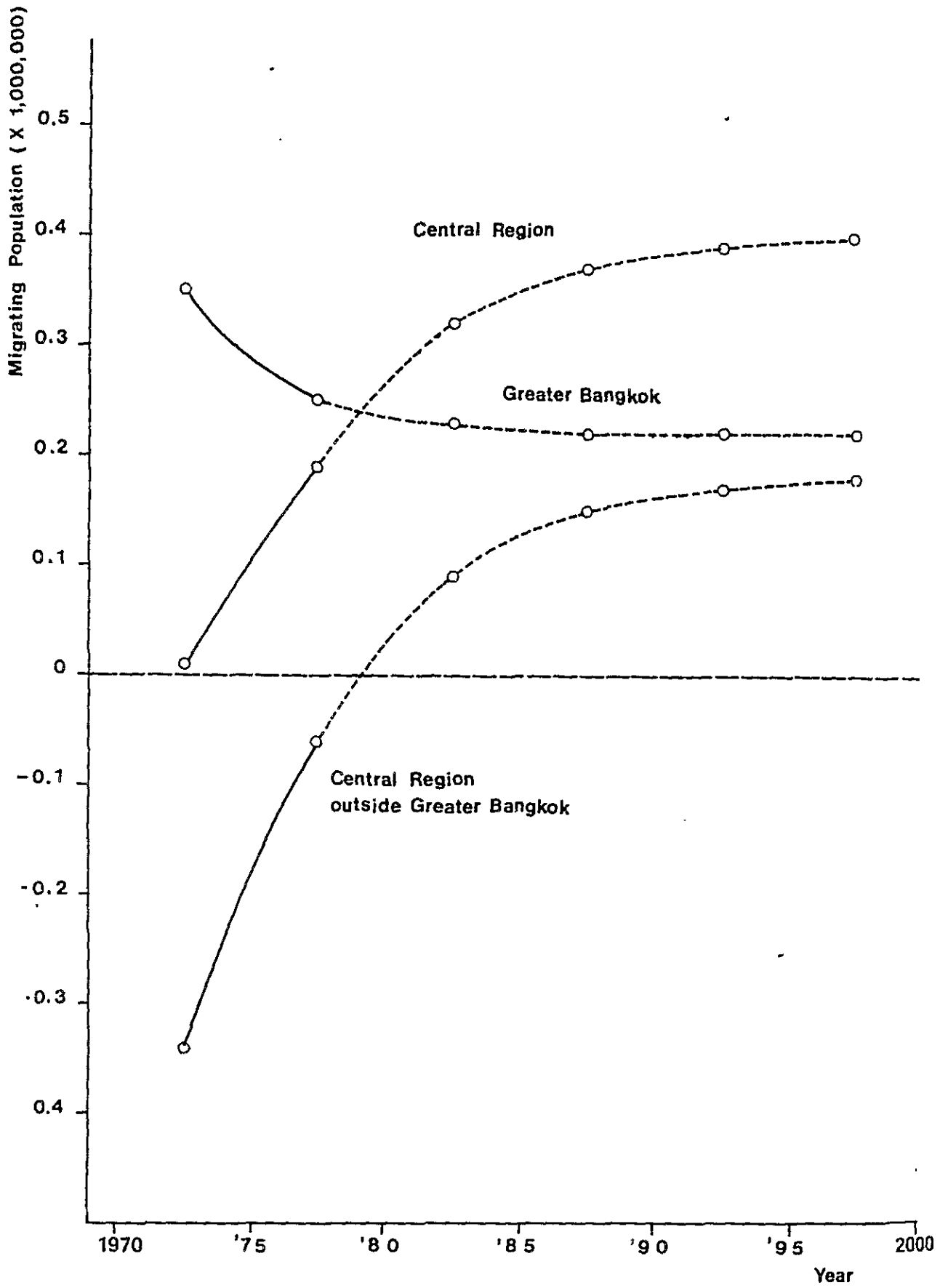


Table 4-3 POPULATION PROJECTION

(Unit: 1 million persons (%))

	Greater Bangkok		Central Region outside Greater Bangkok		Central Region	
Total pop. 1970	4.12		7.74		11.86	
Increase in (Av. Ann. 5 yrs. Period %)	1.01	(4.5)	0.82	(2.0)	1.83	(2.9)
a) Natural Increase (%)	0.66	(3.0)	1.16	(2.8)	1.82	(2.9)
b) Migration Increase (%)	0.35	(1.5)	-0.34	(-0.8)	0.01	(-)
Total pop. 1975	5.13		8.56		13.69	
Increase in (Av. Ann. 5 yrs. Period %)	0.90	(3.3)	1.01	(2.3)	1.91	(2.6)
a) Natural Increase (%)	0.65	(2.4)	1.07	(2.4)	1.72	(2.4)
b) Migration Increase (%)	0.25	(0.9)	-0.06	(-0.1)	0.19	(0.2)
Total pop. 1980	6.03		9.57		15.60	
Increase in (Av. Ann. 5 yrs. Period %)	0.96	(3.0)	1.15	(2.3)	2.11	(2.5)
a) Natural Increase (%)	0.73	(2.3)	1.06	(2.1)	1.79	(2.2)
b) Migration Increase (%)	0.23	(0.7)	0.09	(0.2)	0.32	(0.3)
Total pop. 1985	6.99		10.72		17.71	
Increase in (Av. Ann. 5 yrs. Period %)	0.94	(2.6)	1.27	(2.3)	2.21	(2.4)
a) Natural Increase (%)	0.72	(2.0)	1.12	(2.0)	1.84	(2.0)
b) Migration Increase (%)	0.22	(0.6)	0.15	(0.3)	0.37	(0.4)
Total pop. 1990	7.93		11.99		19.92	
Increase in (Av. Ann. 5 yrs. Period %)	1.02	(2.5)	1.32	(2.1)	2.34	(2.2)
a) Natural Increase (%)	0.80	(1.9)	1.15	(1.9)	1.95	(1.9)
b) Migration Increase (%)	0.22	(0.6)	0.17	(0.2)	0.39	(0.3)
Total pop. 1995	8.95		13.31		22.26	
Increase in (Av. Ann. 5 yrs. Period %)	1.16	(2.4)	1.31	(1.9)	2.47	(2.1)
a) Natural Increase (%)	0.94	(1.9)	1.13	(1.8)	2.07	(1.8)
b) Migration Increase (%)	0.22	(0.5)	0.18	(0.1)	0.40	(0.3)
Total pop. 2000	10.11		14.62		24.73	

Source: Estimated by the Team

4.2.3 Economically Active Population

The employed population by type of industry in 1976 comes from the 'Report of the Labor Force Survey' NSO, 1976. (civilian non-institutional population only.) For the purpose of zonal allocation later, types of industry are classified into three sectors.

- Sector I : Agricultural Sector
- Sector II : Industrial Sector
- Sector III: Commercial/Administrative Sector

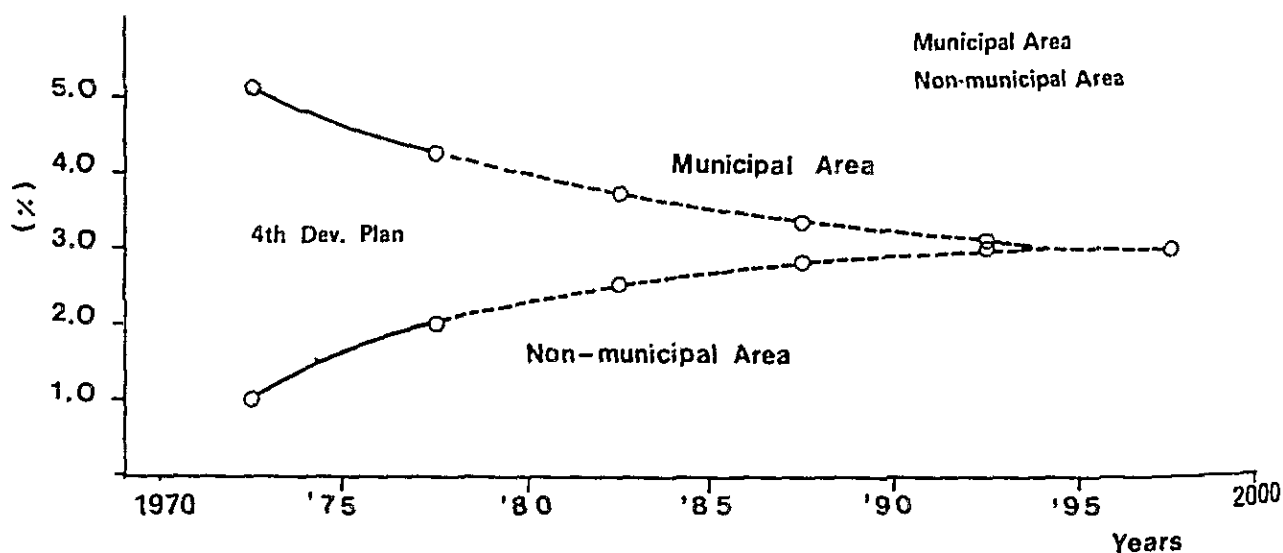
Table 4-4 SECTOR CLASSIFICATION OF INDUSTRIES

Classification in 'Report of the Labor Force Survey'	Sector
- Agriculture, Fishery, Hunting and Fishing	I
- Mining and Quarrying	II
- Manufacturing	II
- Construction, Repair and Demolition	II
- Electricity, Gas, Water and Sanitary Services	III
- Commerce	III
- Transport, Storage and Communication	III
- Services	III
- Activities not Adequately Described	III

The Fourth Development Plan sets the growth rate of employed population both in the municipal and non-municipal*7 areas during the planning period at 4.6% and 2.0%. The future employed population after 1981 is estimated based on the above figures.

Notes: *7 The municipal area is more densely populated than the non-municipal area. Usually, principal regional centers are located in municipal areas.

Fig. 4-4 GROWTH RATE OF EMPLOYMENT



The future sector composition for the economically active population within Greater Bangkok follows that of job opportunity in 'Greater Bangkok Plan'. The DTCP is now working on regional planning for the principal cities outside Greater Bangkok to give them more self-sufficient characters. In these regions, it is foreseeable that the proportion of the secondary and tertiary employment will increase in the future. For the employment in the primary sector, The Fourth Development Plan urges increases in the productivity of the agricultural sector*⁸, and therefore, contrary to the decrease of workers in the primary sector in Greater Bangkok, an increase in the rest of the Central Region will occur.

Notes: *⁸ 4.1.2 Lack of New Agricultural Technology at Farm Level, The Fourth Development Plan.

Table 4-5 EMPLOYMENT STRUCTURE

(Unit: 1,000 Persons)

		1977	1990	2000
GBA	- Residential Pop.	5,560.0	7,930.0	10,110.0
	- Total Employed*)	1,504.5	2,361.0	3,177.2
	- Rate of Employment (%)	(27.1)	(29.8)	(31.4)
	- Sector I (%)	163.7 (10.9)	120.0 (5.1)	60.0 (1.9)
	- Sector II (%)	447.4 (29.7)	750.0 (31.8)	1,080.0 (34.0)
	- Sector III (%)	893.4 (59.4)	1,491.0 (63.1)	2,037.2 (64.1)
Central Region Outside GBA	- Residential Pop.	8,910.0	11,990.0	14,620.0
	- Total Employed *)	2,002.6	2,827.4	3,772.5
	- Rate of Employment (%)	(22.5)	(23.6)	(25.8)
	- Sector I (%)	1,094.2 (54.6)	1,360.0 (48.1)	1,619.1 (42.9)
	- Sector II (%)	317.2 (15.8)	500.0 (17.7)	740.2 (19.6)
	- Sector III (%)	591.2 (29.6)	967.4 (34.2)	1,413.2 (37.5)
Central Region	- Residential Pop.	14,470.0	19,920.0	24,730.0
	- Total Employed *)	3,567.1	5,188.4	6,949.7
	- Rate of Employment (%)	(24.2)	(26.0)	(28.1)
	- Sector I (%)	1,257.9 (35.9)	1,480.0 (28.5)	1,679.1 (24.2)
	- Sector II (%)	764.6 (21.8)	1,250.0 (24.1)	1,820.2 (26.2)
	- Sector III (%)	1,484.6 (42.3)	2,458.4 (47.4)	3,450.4 (49.6)

Notes : The employed population does not include unpaid family workers who were considered as non-commuters. When unpaid family workers are included, the rate of employment in Greater Bangkok rises to 29.2% in 1976.

Source: Estimated by the Team

4.2.4 Workers at Work Places

(1) Commuting Workers

The number of workers at work places is calculated based on the economically active population, taking commuting workers into account. In this study an assumption is made that there is no commuting, or if any it is negligible, between the Central Region and the rest of the Kingdom. The total workers at work places in Greater Bangkok is computed by adding the "in-flow" commuting workers^{*)9} to and by subtracting the "out-flow" commuting workers from the total economically active population in Greater Bangkok.

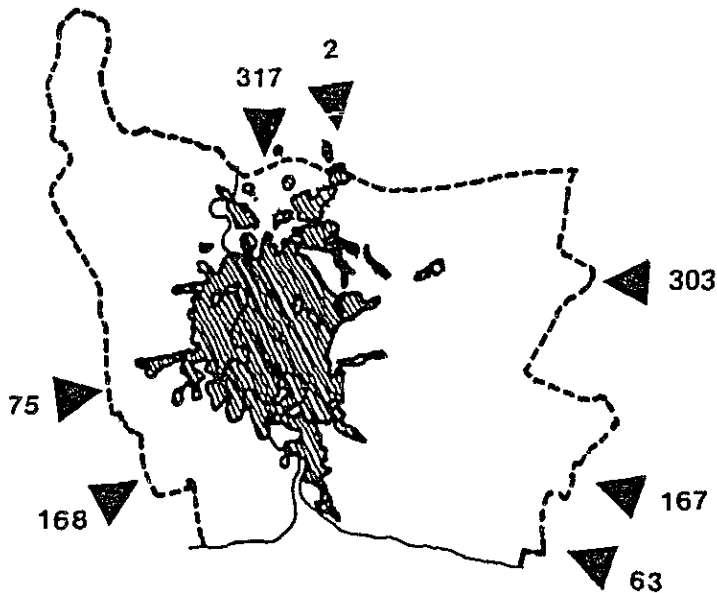
Note: ^{*)9} "In-flow" commuting workers live in the Central Region outside Greater Bangkok and commute into Greater Bangkok to work, and "Out-flow" commuting workers do vice versa.

Among transportation modes of commuting, water transportation is not considered in this study because the traffic volume is very small. Motor vehicles and railway are taken into consideration.

a) Commuting by Motor Vehicles

The traffic volume comes from the traffic counting survey by Dept. of Highway made at counting stations in major directions on the Greater Bangkok border.

Fig. 4-5 TRAFFIC COUNTING STATIONS



(Station numbers and locations along the GBA border)

Table 4-6 DAILY TRAFFIC VOLUME ON GREATER BANGKOK BORDER
BY VEHICLE TYPES & DIRECTIONS, 1977

(Unit: Vehicles/Day)

Station No.	Sedan & Taxi	Light Bus	Heavy Bus	Light Truck	Heavy Truck	Truck over 2 Axles	Total
63	601	635	98	625	1,158	12	3,129
75	25,807	3,615	3,823	3,823	4,363	125	41,556
167	6,265	828	1,077	1,598	2,682	1,327	13,777
168	2,731	421	602	982	997	1,029	6,762
303	635	125	100	125	141	214	1,340
2	11,474	3,867	2,889	2,931	2,952	4,560	28,673
317	4,749	372	482	1,270	2,206	1,107	10,186
Total	52,262	9,863	9,071	11,354	14,499	8,374	105,423

Source: Department of Highways

The average number of passengers for a taxi and sedan is computed by the number of vehicles, frequency of vehicle trip, rate of operation and the number of person trips by vehicle types.

Table 4-7 AVERAGE NUMBER OF PASSENGERS FOR TAXI & SEDAN

	(Unit: Trips/Vehicle-Day) Person Trips by Vehicle Type	Vehicles Number of Vehicles	Trips/Day Frequency of Trips	Rate of Operation	Passengers/Vehicle) Average Number of Passengers
Sedan	1,035,000	176,900	3.5	0.95	1.76
Taxi	346,000	9,350	24.0	0.95	1.62

Source: Bangkok Transportation Study, 1972

The average number of passengers for heavy and light busses is computed by the capacity of a vehicle and the occupancy rate.

Table 4-8 AVERAGE NUMBER OF PASSENGERS FOR BUS

	(Unit: Passenger/ Vehicle) Capacity	Daily Occupancy Rate (%)	Average Number of Passengers
Heavy Bus	65	30	20.0
Light Bus	15	30	4.5

Source: Assumption in accordance with the comment from BMTA and survey result of BTS (1972).

Assuming that sedans occupy 95% of the total traffic volume classified into Sedan & Taxi in Table 4-6 and that commuting by trucks is negligible, the number of daily passengers is computed as follows:

Sedan	:	52,262 x 0.95 x 1.76 =	87,382
Taxi	:	52,262 x 0.05 x 1.62 =	4,233
Light Bus:		9,863 x 4.5 =	44,384
Heavy Bus:		9,071 x 20.0 =	181,420
<hr/>			
Total			317,419 Passengers

Person-trips with the purpose of commuting to work occupies 15%^{*)10} of the total number of person trips in Greater Bangkok, and therefore, the total commuting workers trips by motor vehicles crossing the Greater Bangkok border is as follows:

Note: *)10 An occupancy of person - trips for work (15% of the total number of person - trips in GBA) was taken from RTS (1972).

$$317,419 \times 0.15 = 47,613 \text{ Person.Trips/Day}$$

Assuming the ratio between the volume of the in-flow and out-flow traffic during peak hours (70:30)^{*11} and the percentage of commuting workers in the total passengers in each direction (90% of in-flow Passengers and 10% of out-flow)^{*3} the percentage of in-flow and out-flow commuters in the total passengers is calculated as follows:

Note: *11 The assumptions stated in this paragraph were taken from DOH and SRT, respectively.

$$\begin{aligned} \text{In-flow} &: 0.7 \times 0.9 = 0.63 \text{ (95\%)} \\ \text{Out-flow} &: 0.3 \times 0.1 = 0.03 \text{ (5\%)} \end{aligned}$$

Consequently, the ratio between in flow and out-flor commuters is assumed to be 95:5.

b) Commuting by Railway:

From the O-D survey by the State Railway of Thailand, passengers crossing the Greater Bangkok border during a day in 1977 is as follows:

Commuters:	6,076 ^{*12}	(20%)
Others	24,354	(80%)
<hr/>		
Total	: 30,430 Passengers/Day	(100%)

Notes: *12 This figure is for both directions; for the actual number of commuters it has to be divided by two.

Here, an assumption is made that the number of out-flow commuting workers is negligible compared with that of in-flow,

while in the motor vehicle portion the out-flow commuting passengers occupy 5% of the total commuting passengers.

The ratio between workers and students in the railway commuters is taken from that in the total person-trips by public transport, 55:45.

c) Number of Commuting Workers by Motor Vehicles and Railway
Railway

By adding the motor vehicle portion and railway portion the total in-flow and out-flow commuting workers are obtained.

Table 4-9 IN-FLOW & OUT-FLOW OF COMMUTING WORKERS BY
TRANSPORTATION MODES, 1977

(Unit: Persons)			
Modes	In-flow	Out-flow	Total
Motor Vehicle	45,232	2,381	47,613
Railway	1,692	-	1,692
Total	46,924	2,381	49,305

Source: Estimated by the Team.

(2) Future Commuting Situation

The future commuting workers are estimated assuming that the ratio between the total commuting workers and the total economically active population within the Central Region at present (1.4%) remains the same in the future, and also that the ratio between the in-flow and out-flow commuting workers (at present 95:5) will remain the same.

Table 4.10 FUTURE PROJECTED NUMBER OF COMMUTING WORKERS

(Units: 1,000 Persons)		
	1977	2000
Economically Active Population	3,507.1	6,949.7
Commuting Workers	49.3	97.7
In-flow Commuting Workers	46.9	92.9
Out-flow Commuting Workers	2.4	4.8

Source: Estimated by the Team.

(3) Sector Composition of Commuters

Since primary sector workers do not often commute, the total commuting workers are in the secondary and tertiary sectors. There is no data available about the occupation of commuting workers, and so, in-flow and out-flow commuting workers are classified

into sectors in proportion to the present and future ratio of economically active population for both the Greater Bangkok Area and the Central Region.

Table 4.11 SECTOR COMPOSITION OF COMMUTING WORKERS

(Unit: 1,000 Persons)

		1977	1990	2000
In-flow	Sector II	15.7	23.1	32.1
	Sector III	31.2	45.9	45.9
Out-flow	Sector II	0.8	1.2	1.2
	Sector III	1.6	2.4	2.4
Excess In-flow	Sector II	14.9	21.9	20.9
	Sector III	23.6	43.5	43.5

Source: Estimated by the Team.

(4) Workers at Work Places by Sectors

By adding excess in-flow commuting workers in the secondary and tertiary sectors to the economically active population in each sector in Greater Bangkok, the total workers at work places in each sector in Greater Bangkok are obtained.

By subtracting them from the economically active population in the secondary and tertiary sectors in the Central Region, workers at work places in each sector in the Central Region outside Greater Bangkok is obtained.

Table 4-12 WORKERS AT WORK PLACES BY SECTORS (Unit: 1,000 persons)

		1977	1990	2000
GBA	- Total Workers at Work Places	1,549.0	2,426.4	3,265.3
	- Sector I (%)	163.7(10.6)	120.0(4.9)	(1.8)
	- Sector II (%)	462.3(29.8)	771.9(31.8)	1,110.4(34.0)
	- Sector III (%)	923.0(59.6)	1,534.5(63.3)	2,094.9(64.2)
Central Region outside GBA	- Total Workers at Work Places	1,958.1	2,762.0	3,684.4
	- Sector I (%)	1,094.2(55.9)	1,360.0(49.2)	1,619.1(43.9)
	- Sector II (%)	302.3(15.4)	478.1(17.3)	709.8(19.3)
	- Sector III (%)	561.6(28.7)	923.9(33.5)	1,355.5(36.8)
Central Region	- Total Workers at Work Places	3,507.1	5,188.4	6,949.7
	- Sector I (%)	1,257.9(35.9)	1,480.0(28.5)	1,679.1(24.2)
	- Sector II (%)	764.6(21.8)	1,250.0(24.1)	1,820.2(26.2)
	- Sector III (%)	1,484.6(42.3)	2,458.4(47.4)	3,450.4(49.6)

Source: Estimated by the Team.

4.2.5 Traffic-Relevant Students

(1) General

The number of students which is relevant to commuting traffic consists of the following: students of upper secondary schools, vocational schools (upper level), teacher training schools (diploma level) and higher education.

(2) Upper Secondary School

In Thailand, the schooling system was officially transformed from a 4:3:3:2 system to a 6:3:3 system in 1978. However, in this study the last grade of the lower secondary level is considered to be the upper secondary level in 1977, which is the base year of this study.

During the period 1971 to 1976, the number of students at the secondary level increased at the average annual rate of 12.5%. The Fourth Development Plan sets the goal to increase the number of secondary level students at the annual rate of 11.0% during the planning period.

It is assumed that it would increase at the annual rate of 7.7% during the period 1981 to 2000, reaching 9.0%*)¹³ of the total residential population in 2000.

Notes: *)¹³ In Japan 11.2% in 1965 and 8.1% in 1976.

At present the ratio between the students at the lower and upper level is 75:25, and it is assumed that it would change to 60:40*)¹⁴ by 2000.

Notes: *)¹⁴ In Japan 50:50 in 1965 and 52:48 in 1976.

At present 55% and 35% of the total secondary school students are in the Central Region and Greater Bangkok respectively. The Fourth Development Plan aims at dispersion of educational opportunity to rural areas, and the above ratios are assumed to become 45% and 30% in the Central Region and Greater Bangkok.

(3) Vocational School

The number of vocational school students excluding lower level students has increased at an annual rate of 5.8% during the period 1971 to 1977. The Fourth Development Plan sets the goal to increase the number of students at an annual rate of 8.0% and 15.0% respectively for the secondary and higher levels. In this study, the total students of these two levels are assumed to increase at an annual rate of 10.0% after 1981. Consequently, vocational school students amount to 1.6%*)¹⁵ of the total residential population in 2000.

Notes: *)¹⁵ In Japan 1.4% in 1965 and 0.97% in 1976.

(4) Teacher Training School

The Fourth Development Plan sets the goal to increase the higher diploma level students up to 58,000^{*)16} persons while reducing the lower diploma level students.

Notes: ^{*)16} 56,600 in 1976.

In this study it is assumed that the higher diploma level students would increase at the same rate as planned for the period 1977 to 1981 even until 2000.

(5) Higher Education ^{*)17}

Notes: ^{*)17} It should be noted that higher education students live at study places rather than at residential places for other sectors.

Students enrolled in the higher education has increased at the average annual rate of 1.9% during the period 1971 to 1977. The Fourth Development Plan aims at increasing students at the rate of 4.0% during the planning period. It is assumed that students enrolled in the higher education will amount to 0.3%^{*)18} of the total residential population in 2000.

Notes: ^{*)18} In Japan 0.59% in 1955 and 1.60% in 1976.

At present 89% of higher educational institutions are concentrated in Greater Bangkok, and in 2000 this rate is assumed to decrease to 80%.

(6) Commuting Students

As in section 4.2.4 "Workers at Work Places", commuter students who cross the Greater Bangkok border are calculated for motor vehicle and railway portions.

Table 4-13 COMMUTING STUDENTS BY TRANSPORT MODES, 1977

(Unit: Persons/Day)	
Motor Vehicles	26,980
Railway	1,367
Total	28,347

Source: Estimated by the Team.

Since there are no higher educational institution outside Greater Bangkok in the Central Region, no out-flow commuting student is assumed.

For students in upper secondary, vocational and teacher training schools, the total number of commuting students is divided into those of in-flow and out-flow by the ratio between the number of students in Greater Bangkok and the rest of the Central Region.

At present commuting students amount to 29.4% of the total commuters and it is assumed that this percentage would decrease to around 10.0%*)¹⁹ in 2000.

Notes: *)¹⁹ 3.4% of the total students in the Central Region, while at present, commuting students are 8.6% of the total students in the Central Region. Commuting workers are 1.4% of the total economically active population.

By the number of commuting higher educational students, the total number of higher educational students at study places is adjusted to that of residential places.

Table 4-14 NUMBER OF TRAFFIC-RELEVANT STUDENTS

(Unit: 1,000 students)

		1977	1990	2000
GBA	- Upper Secondary, Vocational & Teacher Training	168.6	729.9	1,161.6
	- Higher Education	59.8	122.1	170.1
	- Total	228.4	852.0	1,331.7
Central Region outside GBA	- Upper Secondary, Vocational & Teacher Training	96.4	370.1	580.7
	- Higher Education	5.4	13.8	20.2
	- Total	101.8	383.9	600.9
Central Region	- Upper Secondary, Vocational & Teacher Training	265.0	1,100.0	1,742.3
	- Higher Education	65.2	135.9	190.3
	- Total	330.2	1,235.9	1,932.6

Source: Estimated by the Team.

4.3 Zone Division and Landuse

4.3.1 Zone Division of Study Area

(1) Greater Bangkok

Zone division of the study area is done primarily based on administrative units which are summarized in Table 4-15.

Table 4.15 ADMINISTRATIVE UNITS IN GREATER BANGKOK

(Unit: Administrative Unit)

Changwat	No. of Amphoe	No. of Tambons
Phra Nakhon	15	98
Thonburi	9	51
Samut Prakan	4	43
Nonthaburi	6	46
Total GBA	34	238

Tambons are considered to be the smallest entity; therefore, no Tambon is divided into a zone.

Studies were made of zone division by past studies such as "Bangkok Transportation Study", "Feasibility Study for the Outer Bangkok Ring Road" and "First Stage MTS in Bangkok. However, for the purpose of this study, the suburban area is divided into smaller zones than in the above past studies. (For a comparison of zone divisions used in this report with those of previous studies, see Appendix Table AP4-2.)

Other factors taken into considerations are: the future landuse plan, future road network, railway network, and mass transit system network and its proposed extension.

(2) Outside Greater Bangkok

For outside Greater Bangkok, Changwats are considered to be the smallest entities except for areas around the Greater Bangkok border where Amphoes are used as zones.

Zone division is done mainly by taking the railway network into consideration.

For the rest of the Kingdom outside the Central Region each region (North-east, North and South) is considered to be an independent zone.

Table 4-16 NUMBER OF ZONES IN THAILAND (Unit: Zones)

Greater Bangkok	71
Outside Greater Bangkok	20
Total	91

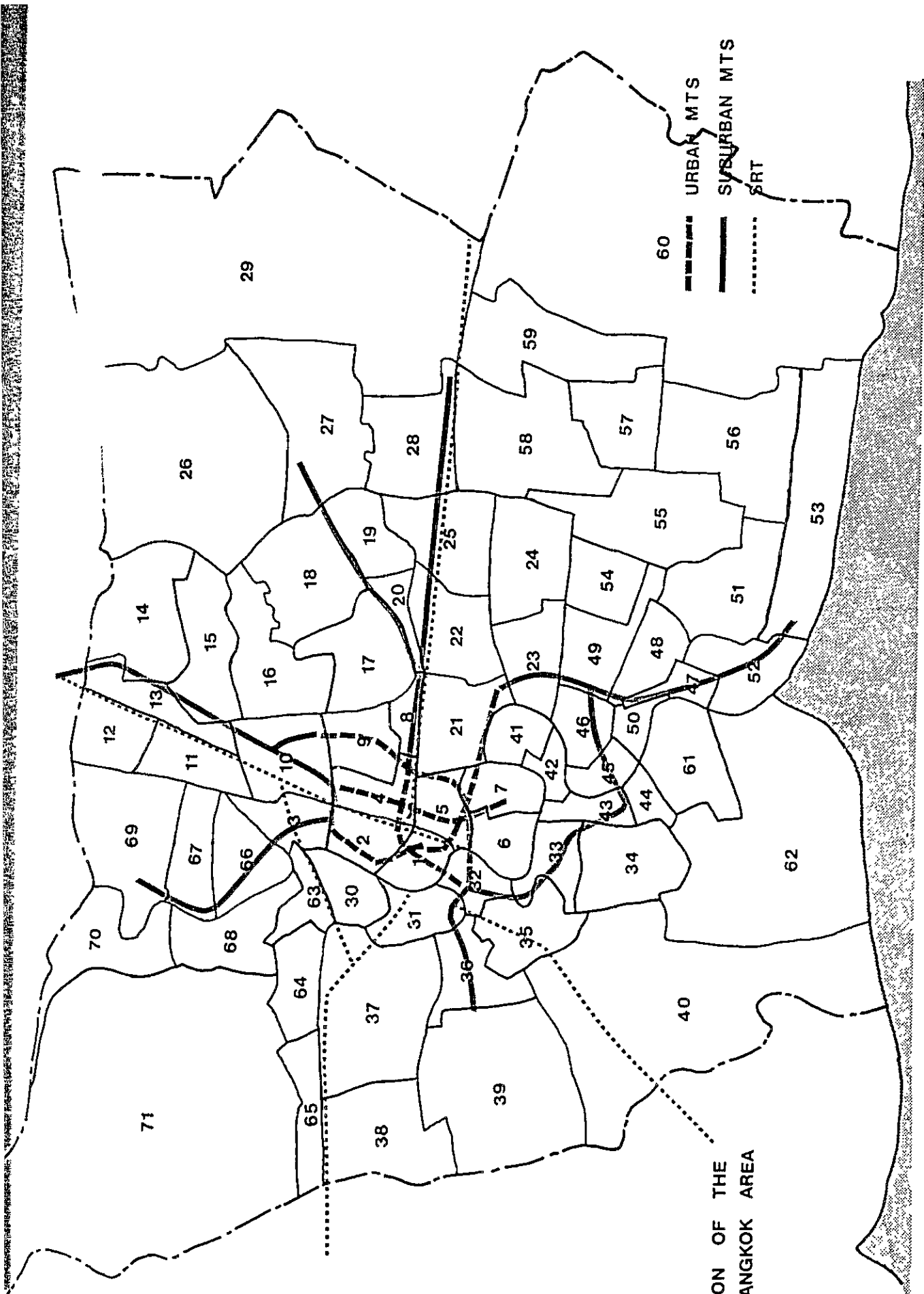


Fig. 4 - 6
 ZONE DIVISION OF THE
 GREATER BANGKOK AREA

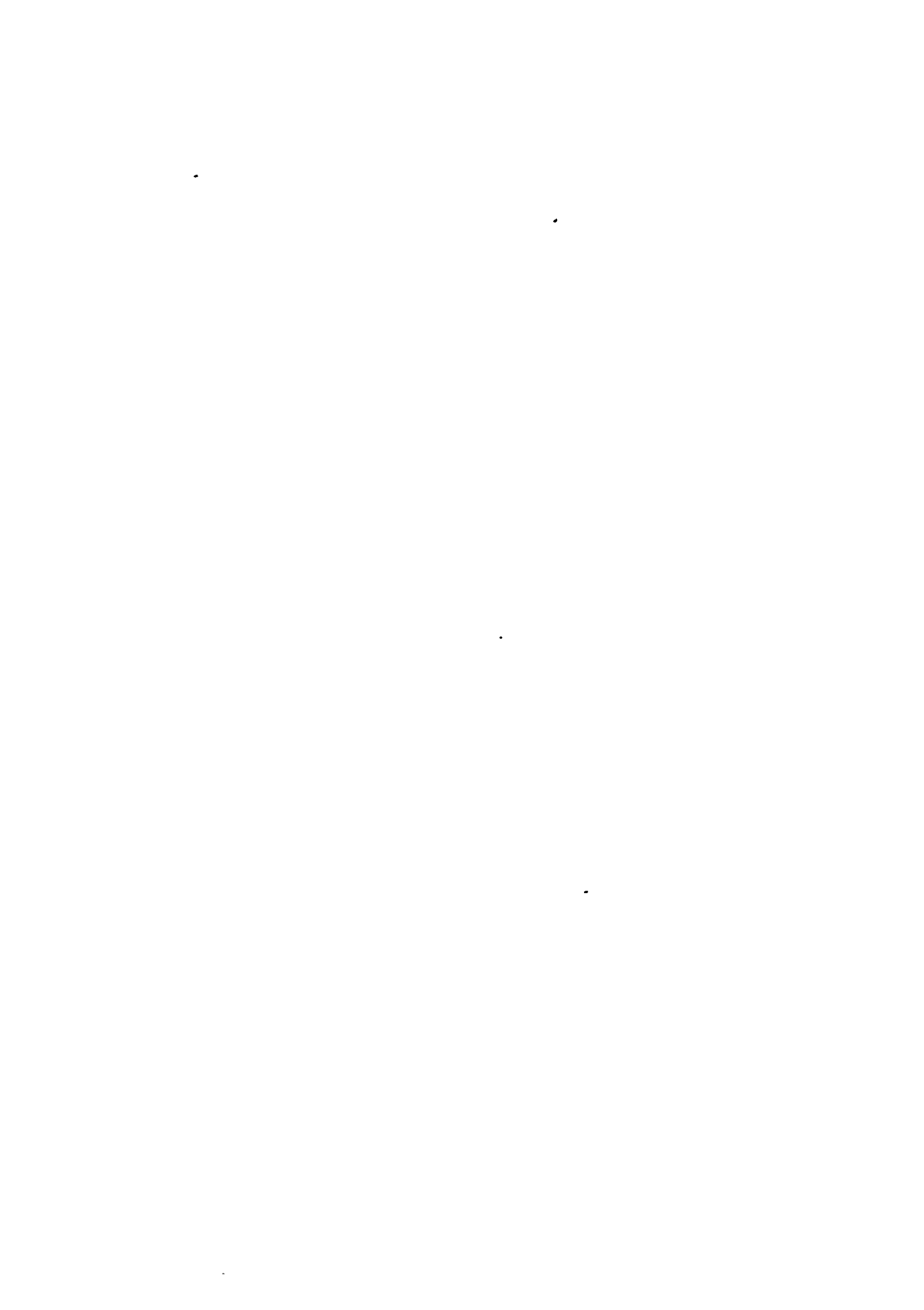


Fig. 4-7 ZONE DIVISION OUTSIDE GREATER BANGKOK AREA

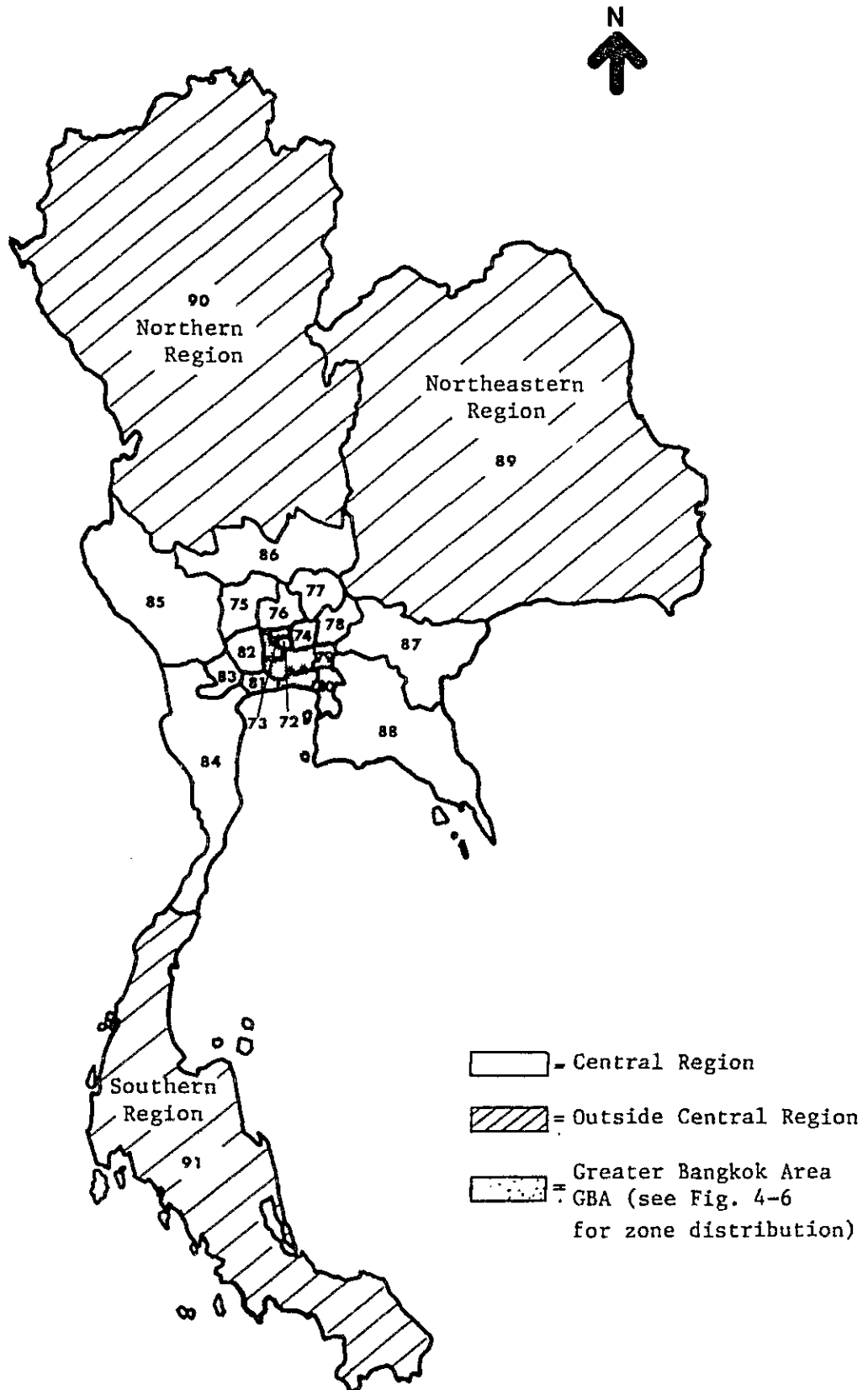


Table 4-17 ZONE CODE TABLE*)

Central Region
Greater Bangkok Area

Zone Number	Name of Zone	Changwat	Amphoe	Tambon
1.	Phra Nakhon	Phra Nakhon	Phra Nakhon	Bang Khun Prom Ban Tan Tom Wat Sam Phra Ya Chana Song Khram Talat Yod Wat Bawonniwet Sao Ching Cha San Chao Po Sue Wat Rachabopit Samranrat Pra Borom Maha Rachawang Wang Burapa
			Pom Prap	Pom Prap Thep Sirin Mahanak Ban Bat Somanat
			Sam Phan Tawong	Songwat Sam Phan Tawong Talat Noi
2.	Dusit	Phra Nakhon	Dusit	Dusit Wachira Phayaban Suan Chitrada Siyak Mahanak Thanon Nakhorn Chaisri
3.	Bang Su		Dusit	Bang Su
4.	Phayathai		Phayathai	Samsen Nai Thanon Phetchaburi Thung Phayathai Makkasan Thanon Phayathai
5.	Pathumwan		Pathumwan	Rong Muang Wang Mai Pathumwan Suan Lumpini
		Bang rak	Maha Phuttaram Siphaya Suriwong Bang rak Silom	

* The Official System of Romanization of Thai place names is listed
in Appendix Table AP4-1.

Zone Number	Name of Zone	Changwat	Amphoe	Tambon
6.	Yannawa	Phra Nakhon	Yannawa	Yannawa Wat Phraya Khrai Bang Kolaem Thung Wat Don Bang Khlo
7.	Bang Pong Pang		Yannawa	Thung Mahamek Bang Pong Pang Chongnonsi
8.	Bang Kapi		Huai Khwang	Bang Kapi
9.	Samsen		Bang Kapi Huai Khwang	Samsen Nok Huai Khwang Ding Daeng
10.	Lat Yao		Bang Khen	Lat Yao
11.	Thung Song Hong		Bang Khen	Song Hong
12.	Thung Si Kan		Bang Khen	Si Kan
13.	Talat Bang Khen		Bang Khen	Talat Bang Khen
14.	Khlong Thanon		Bang Khen	Khlong Thanon Sai Mai O Ngoen
15.	Thareng		Bang Khen	Anusawari Thareng
16.	Lat Phrao		Bang Kapi	Lat Phrao Charakhe Bua
17.	Khlong Chan		Bang Kapi	Khlong Chan Wang Thong Lang
18.	Khlong Kum		Bang Kapi	Khlong Kum Kanna Yao
19.	Saphan Sung		Bang Kapi	Saphan Sung
20.	Huamak		Bang Kapi	Huamak
21.	Phra Khanong		Phra Khanong	Phra Khanong Khlong Tan Khlong Toei
22.	Suan Luang		Phra Khanong	Suan Luang
23.	Bang Na		Phra Khanong	Bang Na Bang Chak

Zone Number	Name of Zone	Changwat	Amphoe	Tambon	
24.	Nong Bon	Phra Nakhon	Phra Khanong	Nong Bon Dok Mai	
25.	Prawet		Phra Khanong	Prawet	
26.	Bang Chan		Minburi	Bang Chan Sai Kong Din Sai Kong Din Tai Samwa Tawan Ok Samwa Tawan Tok	
27.	Minburi		Minburi	Minburi Saen Saep	
28.	Lat Krabang		Lat Krabang	Lat Krabang Khlong Song Tonnun Khlong Sam Prawet	
29.	Nong Chok		Nong Chok	Kra Thum Rai Nong Chok Khlong Sip Khlong Sip Song Kok Faet Khu Fang Nua Lam Phak Chi Lam Toi Ting	
			Lat Krabang	Lam Pla Tiu Tap Yao Khum Thong	
30.	Bang O		Thonburi	Bangkok Noi	Bang Yi Khan Bang Phlat Bang Bamru Bang O
31.	Sirirat			Bangkok Noi	Sirirat Ban Chang Lo Bang Khunnon Bang Khun Sri
		Bangkok Yai		Wat Arun Wat Tha Phra	
32.	Thonburi	Khlong San		Somdet Chao Phraya Khlong San Bang Lampu Lang Khlong Ton Sai	
		Thonburi		Wat Kanyani Hiranruchi Bang Yi Rua Bukhalo Talat Phlu	

Zone Number	Name of Zone	Changwat	Amphoe	Tambon
33.	Rat Burana	Thonburi	Rat Burana	Rat Burana Bang Pakok
34.	Thung Khru		Rat Burana	Bang Mot Thung Khru
35.	Bang Khun Tian		Bang Khun Tian	Chom Thong Bang Khun Tian Bang Mot Bang Kho
36.	Phasi Charoen		Phasi Charoen	Bang Wa Bang Duan Bang Chak Bang Waek Khlong Khwang Pak Khlong Khu Ha Sawan
37.	Taling Chan		Taling Chan	Taling Chan Chim Phli Bang Phrom Bang Ramat Bang Chuak Nang
38.	Sala Tham Masop		Taling Chan	Thawi Watana Sala Tham Masop
39.	Nong Khaem		Phasi Charoen	Bang Khae Bang Khae Nua Bang Phai
			Nong Khaem	Lak Song Nong Khaem Nong Khang Phlu
40.	Bang Bon		Bang Khun Tian	Bang Bon Ta Kham Samae Dam
41.	Bang Ko Bua		Samut Prakan	Pra Pa Daeng
42.	Bang Yo	Pra Pa Daeng		Song Khanong Bang Yo Bang Krasop
43.	Bang Talat	Pra Pa Daeng		Bang Pung Bang Khru

Zone Number	Name of Zone	Changwat	Amphoe	Tambon
44.	Bang Chak	Samut Prakan	Pra Pa Daeng	Bang Chak
45.	Bang Ya Phraek		Pra Pa Daeng	Bang Ya Phraek Bang Hua Sua
46.	Samrong Tai		Pra Pa Daeng	Samrong Tai
47.	Samut Prakan		Samut Prakan	Pak Nam
48.	Bang Muang		Samut Prakan	Bang Muang
49.	Samrong Nua		Samut Prakan	Sam Rong Nua
50.	Bang Duan		Samut Prakan	Bang Duan Bang Prong
51.	Phraek Sa		Samut Prakan	Phraek Sa
52.	Thai Ban		Samut Prakan	Thai Ban
53.	Bang Pumai		Samut Prakan	Bang Pumai Bang Pu
54.	Bang Kaeo		Bang Phli	Bang Kaeo
55.	Bang Phli Yai		Bang Phli	Bang Phli Yai
56.	Bang Pla		Bang Phli	Bang Pla
57.	Bang Chalong		Bang Phli	Bang Chalong
58.	Racha Thewa		Bang Phli	Racha Thewa Nong Pru
59.	Srisa Charakhe		Bang Phli	Srisa Charakhe Noi Srisa Charakhe Yai
60.	Bang Bo		Bang Phli	Bang Sao Thong
			Bang Bo	Khlong Dan Bang Bo Bang Priang Ban Rakat Preng Khlong Suan Niyom Yatra Bang Phli Noi
61.	Bang Pakok		Samut Prakan	Nai Khlong Bang Plakot Pak Khlong Bang Plakot
62.	Laem Fa Pha		Samut Prakan	Laem Fa Pha Naglua

Zone Number	Name of Zone	Changwat	Amphoe	Tambon
63.	Wat Chalo	Nonthaburi	Bang Kruai	Wat Chalo Bang Kruai Bang Sithong
64.	Bang Khanun		Bang Kruai	Bang Khanun Bang Khun Kong Bang Khu Wiang Mana Sawat
65.	Bang Kruai		Bang Kruai	Sala Klang Plai Bang
66.	Nonthaburi		Nonthaburi	Bang Khen Talat Khuan
67.	Bang Kraso		Nonthaburi	Bang Kraso Tha Sai
68.	Bang Krang		Nonthaburi	Bang Krang Bang Phai Bang Si Muang Sai Ma Bang Rak Noi
69.	Pak Kret		Pak Kret	Bang Talat Pak Kret Ban Mai Bang Put Ko Kret
70.	Om Kret		Pak Kret	Om Kret Bang Phlap Khlong Khoi Ta It Bang Ta Nai Khlong Phra Udom
71.	Bang Bua Thong		Bang Bua Thong	Bang Bua Thong Bang Rak Yai Lampho Bang Ku Rat Lahan
			Bang Yai	Bang Muang Bang Mae Nang Bang Len Sao Thong Hin Bang Yai Ban Mai
			Sai Noi	Sai Noi Rat Niyom Nong Prao Ngai Sai Yai Khun Sri

Central Region
Outside the Greater Bangkok Area

Zone Number	Name of Zone	Changwat	Amphoe	Tambon
72.	Pathum Thani	Pathum Thani (1/3)	Muang Pathum Thani	
73.	Sam Khok	Pathum Thani (2/3)	Lat Lum Kaeo Sam Khok	
74.	Khlong Luang	Pathum Thani (3/3)	Khlong Luang Thanyaburi Nong Sua Lam Luk Ka	
75.	Suphanburi	Suphanburi (1/2)	Muang Suphanburi Bang Pla Ma Si Prachan Song Phi Nong U Thong Don Chedi	
		Ang Thong		
76.	Ayuthaya	Phra Nakhon Si Ayuthaya		
77.	Saraburi	Saraburi		
78.	Nakhon Nayok	Nakhon Nayok		
79.	Chachoengsao	Chachoengsao (1/3)	Muang Chachoengsao Bang Nam Phrieo	
80.	Chonburi	Chachoengsao (2/3)	Bang Pra Kong Ban Pho	
		Chonburi (1/2)	Phan Thong Chonburi	
81.	Samut Sakhon	Samut Sakhon		
82.	Nakhon Pathom		Nakhon Pathom	
83.	Ratchaburi	Ratchaburi (1/2)	Muang Ratchaburi Damnoen Saduak Ban Prong Bang Phae Photharam	

Zone Number	Name of Zone	Changwat	Amphoe	Tambon
84.	Samut Songkhram	Ratchaburi (2/2)	Chom Bung Pak Tho Wat Phleng	
		Samut Songkhram		
		Phetchaburi		
		Prachuap Khiri Khan		
85.	Kanchanaburi	Kanchanaburi		
86.	Lopburi	Suphanburi	Doem Bang Nang Buat Sam Chuk	
		Lopburi		
		Singburi		
		Chai Nat		
87.	Prachinburi	Prachinburi		
88.	Rayong	Chachoengsao (3/3)	Bang Khla Phanom Sarakham Sanam Chai	
		Chonburi (2/2)	Sriracha Bang Lamung Satahip Phana Nikhom Ban Bung	
		Rayong		
		Chanthaburi		
		Trat		
89.	Northeast Region			
90.	North Region			
91.	South Region			

4.3.2 Landuse

(1) Existing Landuse

A map of existing landuse in 1976^{*)20}, scale 1:50,000, in Greater Bangkok was provided by DTCP. The area of each landuse was measured on this map, reclassifying landuse items to coincide with those of the future landuse plan in "Greater Bangkok Plan" for the purpose of allocating planning parameters.

Notes: ^{*)20} No change is assumed in the landuse between 1976 and 1977.

Table 4-18 GREATER BANGKOK LANDUSE, 1977

(Unit: Ha)

Classification for this Study	Classification in DTCP Landuse Map	Area
Mixed-use Low Density	Low Density Housing	32,457
Mixed-use High Density	Commercial and High Density Housing	4,571
Institutional	Institutions, Schools, Colleges, Universities and Temples	5,027
Industrial	Industry, Warehouses and Public Utilities	4,293
Agricultural	Farmland and Orchards	255,334
Others	Parks and Water Surfaces, etc.	14,918
Total		316,600*)

Notes : *) The total area of the Greater Bangkok is taken "Statistical Year Book", see Table 4-1.

Source: Measured on the landuse map provided by DTCP.

(2) Future Landuse

The future landuse area was plotted on the latest version of the landuse plan map, scale 1:50,000, provided by DTCP. Minor re-classification of landuse items was done for the purpose of this study. This landuse plan does not cover entire Greater Bangkok, but leaves the east and northeast fringe areas blank since these areas are classified as agricultural landuse. Traditional preservation and recreational areas on the above map are classified into the category of "Others" for the purpose of this study.

Table 4-20 GREATER BANGKOK LANDUSE, 2000

(Unit: Ha)

Landuse	Area
Mixed-use Low Density	72,523
Mixed-use High Density	13,977
Institutional	3,467
Industrial	9,400
Agricultural	203,047
Others	14,186
Total	316,600

Source: Measured on 'Greater Bangkok Plan'

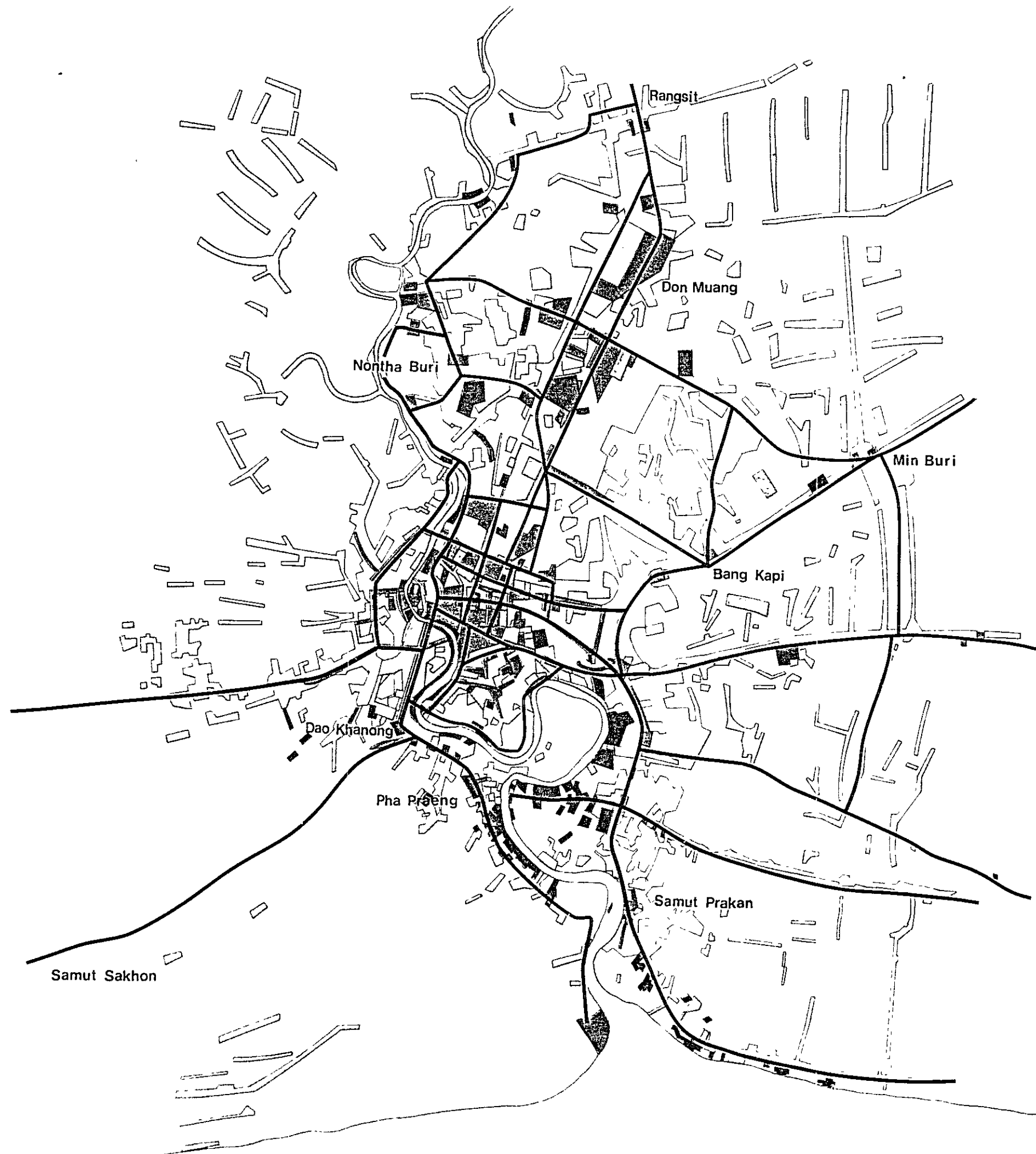
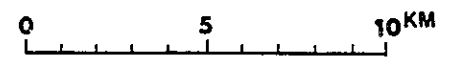


Fig. 4-8
EXISTING GREATER
BANGKOK LANDUSE, 1977




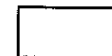






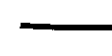
-  COMMERCE
-  MIXED USE, HIGH DENSITY
-  MIXED USE, LOW DENSITY
-  PUBLIC UTILITY
-  INSTITUTIONS
-  PARK
-  SCHOOL, COLLEGE, UNIVERSITY.
-  INDUSTRY
-  EXISTING MAIN ROAD



Table 4-19 GREATER BANGKOK LANDUSE, 1977

								(Unit: Ha)
Zone No.	Name of Zone	Mixed Use Low Density	Mixed Use High Density	Institutional	Industrial	Agricultural	Others	Total
1	Phra Nakhon	23	409	223	59	-	454	1,168
2	Dusit	217	81	545	41	-	241	1,125
3	Bang Su	594	91	22	75	105	451	1,338
4	Phayathai	725	383	444	119	-	55	1,726
5	Pathumwan	192	472	269	13	-	265	1,211
6	Yannawa	266	303	75	131	328	249	1,352
7	Bang Pong Pang	580	128	102	103	276	309	1,498
8	Bang Kapi	363	50	3	14	94	72	596
9	Samsen	1,056	114	30	23	279	180	1,682
10	Lat Yao	2,077	115	397	395	-	408	3,392
11	Thung Song Hong	417	-	214	8	840	216	1,695
12	Thung Si Kan	378	5	42	3	1,516	116	2,060
13	Talat Bang Khen	498	12	291	453	-	358	1,612
14	Khlong Thanon	734	31	388	-	3,113	469	4,735
15	Thareng	1,209	13	406	16	743	913	3,300
16	Lat Phrao	1,419	-	22	9	1,917	-	3,367
17	Khlong Chan	1,514	52	17	33	1,442	-	3,058
18	Khlong Kum	847	16	3	75	3,059	116	4,116
19	Saphan Sung	114	-	-	-	1,473	-	1,587
20	Huamak	289	31	45	30	1,015	97	1,507
21	Phra Khanong	1,597	545	84	194	98	451	2,969
22	Suan Luang	578	36	3	11	1,549	82	2,259
23	Bang Na	1,147	94	1 105	220	1,254	150	2,970
24	Nong Bon	441	8	5	5	2,807	-	3,266
25	Prawet	555	-	-	106	2,968	208	3,837
26	Bang Chan	828	-	-	2	11,293	-	12,123
27	Minburi	513	9	17	36	5,651	2	6,228
28	Lat Krabang	444	19	17	8	3,700	95	4,283
29	Nong Chok	20	-	-	-	32,261	-	32,281
30	Bang O	816	150	22	13	222	206	1,429
31	Siriraj	380	419	120	28	385	325	1,657
32	Thonburi	264	434	73	87	16	582	1,456
33	Rat Burana	431	45	28	220	689	106	1,519
34	Thung Khru	219	5	20	2	2,848	19	3,113
35	Bang Khun Tian	439	94	16	72	1,491	81	2,193
36	Phasi Charoen	450	27	13	62	1,313	66	1,931
37	Taling Chan	366	6	5	6	4,807	-	5,190
38	Sala Than Masop	81	-	-	-	3,514	-	3,595
39	Nong Khaem	1,062	28	86	-	7,444	-	8,620
40	Bang Bon	242	-	-	41	12,273	-	12,556
	Bangkok Metropolis	24,365	4,225	4,152	2,713	112,783	7,342	155,600
41	Bang Ko Bua	77	-	3	28	745	209	1,062
42	Bang Yo	70	-	13	48	584	212	927
43	Bang Talat	128	77	22	144	267	293	931
44	Bang Chak	84	6	6	147	548	58	849
45	Bang Ya Phraek	62	19	9	84	650	175	999
46	Sanrong Tai	133	14	3	403	497	63	1,113
47	Samut Prakan	-	86	65	36	445	320	952
48	Bang Muang	330	-	8	13	1,031	266	1,648
49	Samrong Nua	937	28	6	50	848	90	1,959
50	Bang Duan	116	-	5	2	423	273	819
51	Phraek Sa	336	-	-	2	4,020	-	4,358
52	Thai Ban	333	-	5	123	1,241	41	1,743
53	Bang Pumai	419	8	23	123	2,545	2,266	5,384
54	Bang Kaeo	102	-	-	2	2,477	-	2,581
55	Bang Phli Yai	445	3	3	3	4,363	-	4,817
56	Bang Pla	283	-	-	-	3,094	2,419	5,796
57	Bang Chalong	89	-	-	25	3,013	-	3,127
58	Eacha Thewa	401	-	-	-	5,374	85	5,860
59	Srissa Charakhe	-	-	-	14	5,311	-	5,325
60	Bang Bo	169	9	-	5	28,777	-	28,960
61	Bang Pakok	150	5	16	103	2,263	138	2,675
62	Laem Fa Pha	155	-	219	6	11,235	-	11,515
	Samut Prakan	4,819	255	406	1,361	79,651	6,908	93,400
63	Wat Chalo	166	3	11	23	1,114	51	1,368
64	Bang Khanum	102	-	2	-	2,004	-	2,108
65	Bang Krusi	47	-	-	-	2,137	-	2,184
66	Nonthaburi	651	45	230	27	818	93	1,864
67	Bang Kraso	917	13	75	56	1,137	59	2,257
68	Bang Krang	148	8	6	2	3,066	84	3,314
69	Pak Kret	502	12	134	105	4,306	250	5,309
70	Om Kret	98	8	11	-	3,933	131	4,181
71	Bang Bus Thong	622	2	-	6	44,385	-	45,015
	Nonthaburi	3,253	91	469	219	62,900	668	67,600
	Greater Bangkok Area	32,457	4,571	5,027	4,293	255,334	14,918	316,600

Source: Estimated by the Team.

Table 4-21 GREATER BANGKOK LANDUSE, 2000

(Unit: Ha)

Zone No.	Name of Zone	Mixed Use Low Density	Mixed Use High Density	Institutional	Industrial	Agricultural	Others	Total
1	Phra Nakhon	-	407	33	-	-	728	1,168
2	Dusit	-	217	343	-	-	565	1,125
3	Bang Su	840	-	-	46	-	452	1,338
4	Phayathai	-	859	253	119	-	495	1,726
5	Pathumwan	-	611	93	4	-	503	1,211
6	Yannawa	761	343	-	-	-	248	1,352
7	Bang Pong Pang	786	311	992	-	-	309	1,498
8	Bang Kapi	201	322	-	-	-	73	596
9	Samsen	557	913	33	-	-	179	1,682
10	Lat Yao	1,001	1,097	331	203	-	760	3,392
11	Thung Saong Hong	1,314	-	114	-	-	217	1,695
12	Thung Si Kan	1,394	-	-	-	550	116	2,060
13	Talat Bang Khen	400	69	244	206	213	480	1,612
14	Khlong Thanon	564	241	389	34	3,038	469	4,735
15	Thareng	1,074	-	356	-	925	945	3,300
16	Lat Phrao	-	188	10	-	3,169	-	3,367
17	Khlong Chan	2,706	347	-	-	-	5	3,058
18	Khlong Num	3,208	646	-	56	98	108	4,116
19	Saphan Sung	1,587	-	-	-	-	-	1,587
20	Huanak	1,340	-	64	-	-	103	1,507
21	Phra Khanong	1,048	1,113	-	361	-	447	2,969
22	Suan Luang	2,178	-	-	-	-	81	2,259
23	Bang Na	2,028	260	85	459	-	138	2,970
24	Nong Bon	2,982	284	-	-	-	-	3,266
25	Prawet	3,619	-	-	-	-	218	3,837
26	Bang Chan	483	-	-	-	11,640	-	12,123
27	Minburi	1,664	573	36	109	3,846	-	6,228
28	Lat Krabang	1,062	223	-	10	2,895	93	4,283
29	Nong Chok	966	-	-	726	30,589	-	32,281
30	Bang O	767	454	-	-	-	208	1,429
31	Sirirat	497	249	86	-	-	325	1,657
32	Thonburi	-	858	18	-	-	580	1,456
33	Rat Burana	1,212	208	-	-	-	99	1,519
34	Thung Khru	3,027	58	19	-	-	9	3,113
35	Bang Khun Tian	1,593	294	-	-	224	82	2,193
36	Phasi Charoen	1,663	154	-	-	187	67	1,931
37	Taling Chan	1,054	-	-	-	4,136	-	5,190
38	Sala Than Masop	-	-	-	-	3,595	-	3,595
39	Nong Khaem	1,697	106	-	-	6,817	-	8,620
40	Bang Bo	1,439	-	-	-	11,117	-	12,556
	Bangkok Metropolis	46,712	11,765	2,649	2,333	83,039	9,102	155,600
41	Bang Ko Bua	853	-	-	-	-	209	1,062
42	Bang Yo	660	56	-	-	-	211	927
43	Bang Talat	33	380	-	224	-	294	931
44	Bang Chak	364	-	-	928	-	57	849
45	Bang Ya Phraek	406	131	-	289	-	173	999
46	Samrong Tai	85	-	-	965	-	63	1,113
47	Samut Prakan	112	489	32	-	-	319	952
48	Bang Muang	1,286	86	-	9	-	267	1,648
49	Samrong Nua	1,380	144	-	178	169	88	1,959
50	Bang Duan	501	-	8	37	-	273	819
51	Phraek Sa	4,206	-	-	138	-	14	4,358
52	Thai Ban	1,030	-	-	679	-	34	1,743
53	Bang Pumai	685	-	-	853	1,657	2,189	5,384
54	Bang Kaeo	1,997	17	-	-	567	-	2,581
55	Bang Phli Yai	-	-	-	-	4,817	-	4,817
56	Bang Pla	-	-	-	-	5,796	-	5,796
57	Bang Chalong	-	-	-	6	3,121	-	3,127
58	Racha Theva	184	71	-	2,739	2,782	84	5,860
59	Srisa Charakhe	149	-	-	-	5,176	-	5,325
60	Bang Bo	-	-	-	-	28,960	-	28,960
61	Bnag Pakok	1,975	-	-	485	77	138	2,675
62	Laem Fa Pha	279	-	-	-	11,236	-	11,515
	Samut Prakan	16,185	1,374	40	7,030	64,358	4,413	93,400
63	Wat Chalo	1,280	-	-	37	-	51	1,308
64	Bang Khanum	450	-	-	-	1,558	-	2,108
65	Bang Kruai	-	-	-	-	2,184	-	2,184
66	Nonthaburi	1,182	204	385	-	-	93	1,864
67	Bang Kraso	1,511	542	146	-	-	59	2,257
68	Bang Krang	1,873	-	-	-	1,357	84	3,314
69	Pak Kret	3,330	92	267	-	1,386	254	5,309
70	Om Kret	-	-	-	-	4,050	131	4,181
71	Bang Bua Thong	-	-	-	-	45,015	-	45,015
	Nonthaburi	9,626	838	778	37	55,650	671	67,600
	Greater Bangkok Area	72,523	13,977	3,467	9,400	203,047	14,186	316,600

Source: Estimated by the Team.

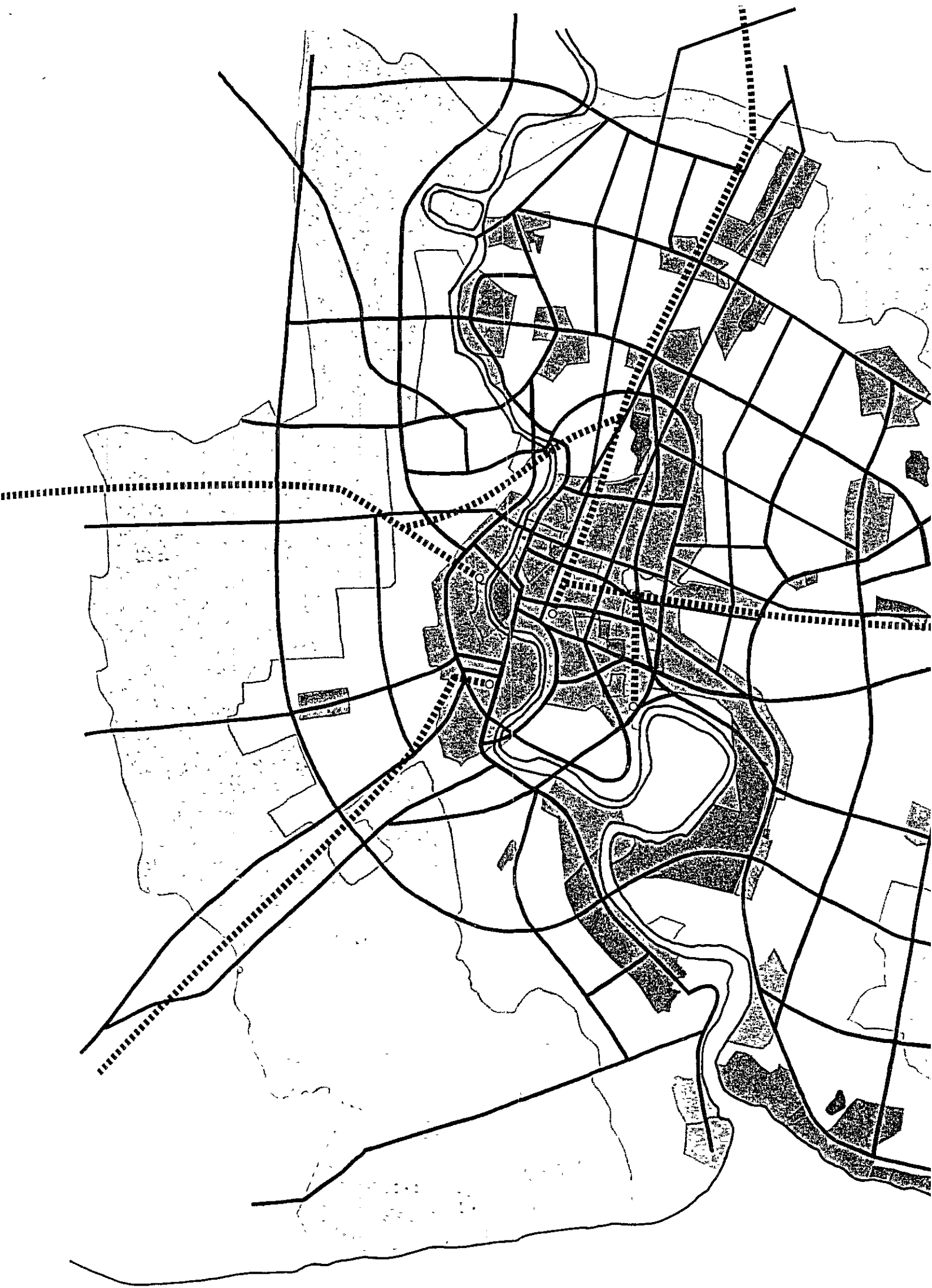
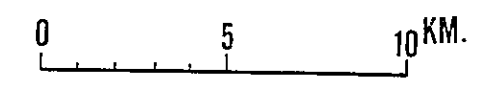
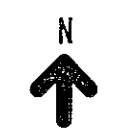
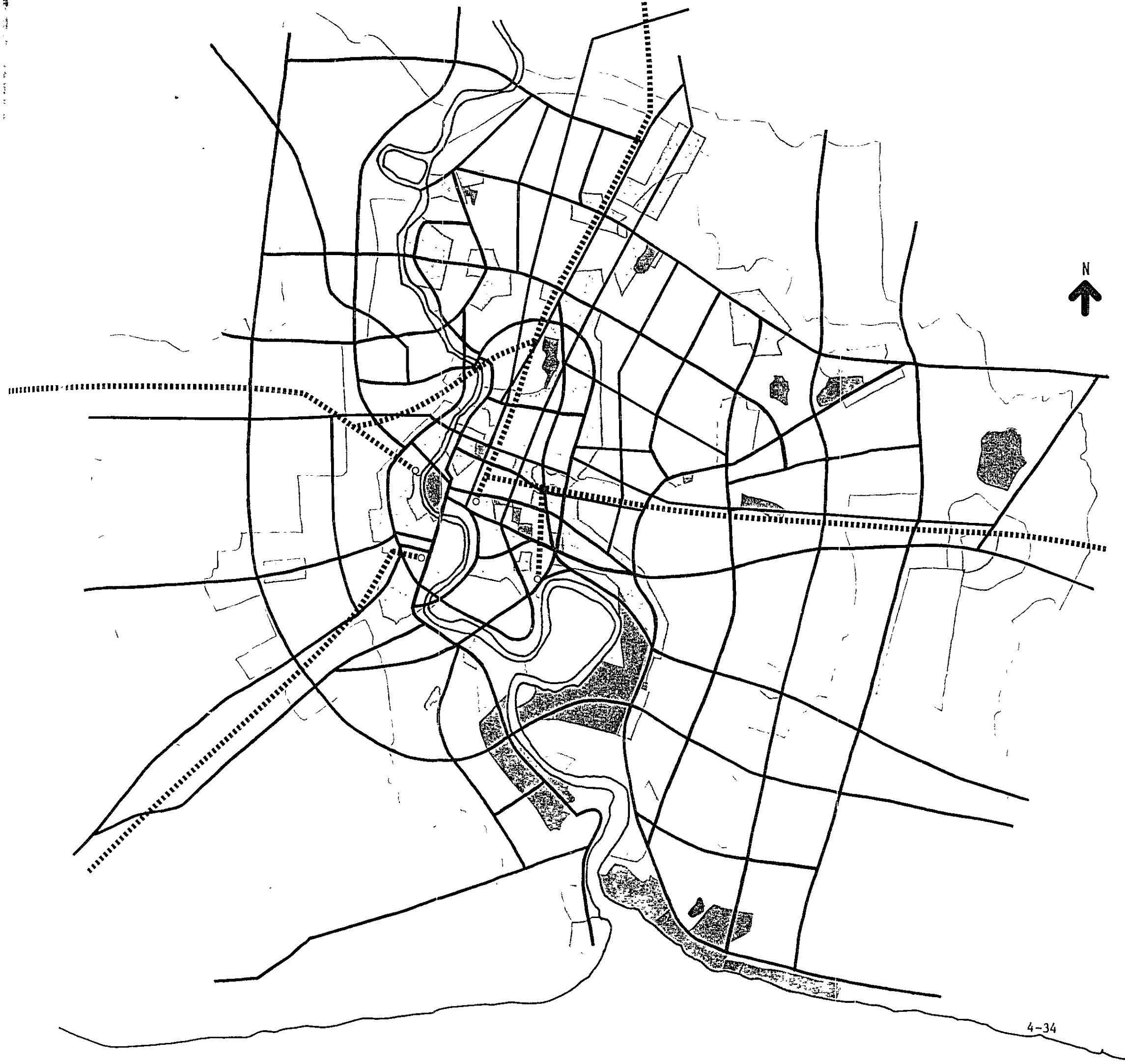


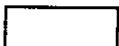


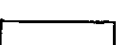
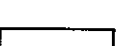




Fig. 4-9
GREATER BANGKOK
LANDUSE PLAN, 2000



-  MIXED USE, LOW DENSITY
-  MIXED USE, HIGH DENSITY
-  INSTITUTIONAL
-  INDUSTRIAL
-  RECREATIONAL
-  AGRICULTURAL
-  PUBLIC UTILITIES
-  EXISTING RAILWAY
-  URBAN PLANNING ROAD

4.4 Zonal Allocation of Planning Parameters

4.4.1 General

Using the figures in 1977 and 2000 set up in Section 4-2 "Statistical Framework" as regional controls, zonal allocation is done for planning parameters such as:

- Residential Population;
- Economically Active Population in Sector I;
- Economically Active Population in Sector II;
- Economically Active Population in Sector III;
- Workers at Work Places in Sector II;
- Workers at Work Places in Sector III; and
- Traffic-Relevant Students.

Since regional planning is still in progress, for the study area outside Greater Bangkok zonal allocation is done only for the residential population for the purpose of the car ownership study in Chapter 5: "TRANSPORTATION PLANNING AND FORECASTS OF FUTURE TRAFFIC DEMAND". The traffic volume of commuters in the future, both of workers and students, by directions is calculated using the directional proportion^{*)21} of their present volume.

Notes: *)21 See Section 4.2.3 "Workers at Work Places".

4.4.2 Residential Population

(1) Present Residential Population by Zones

The residential population by Tambons and Amphoes during the period 1973 to 1978 is listed in the "First Stage MTS in Bangkok, Special Report No. 2, Up-dating of Traffic Data", by Bangkok MTS Consultants, 1978. The above figures are transformed into zonal populations by the zone code list, Table 4-17.

Consequently, the gross population density by zones varies from 348 Persons/Ha in Zone #1 to 1.5 Persons/Ha in Zone #51 in Greater Bangkok. High density areas are found in the central districts such as Zone #1, 2, 3, 4, 5, 31 and 32.

For the Central Region outside Greater Bangkok, zonal residential population during the period 1973 to 1977 is taken from the census provided by Dept. of Local Administration, Ministry of Interior.

(2) Future Residential Population

The future zonal residential population in Greater Bangkok is estimated in two different ways for:

- Zones with relatively high density in the central district;
and
- Zones with low density.

No drastic change in landuse is planned for zones in the central district, and therefore, the past development of residential

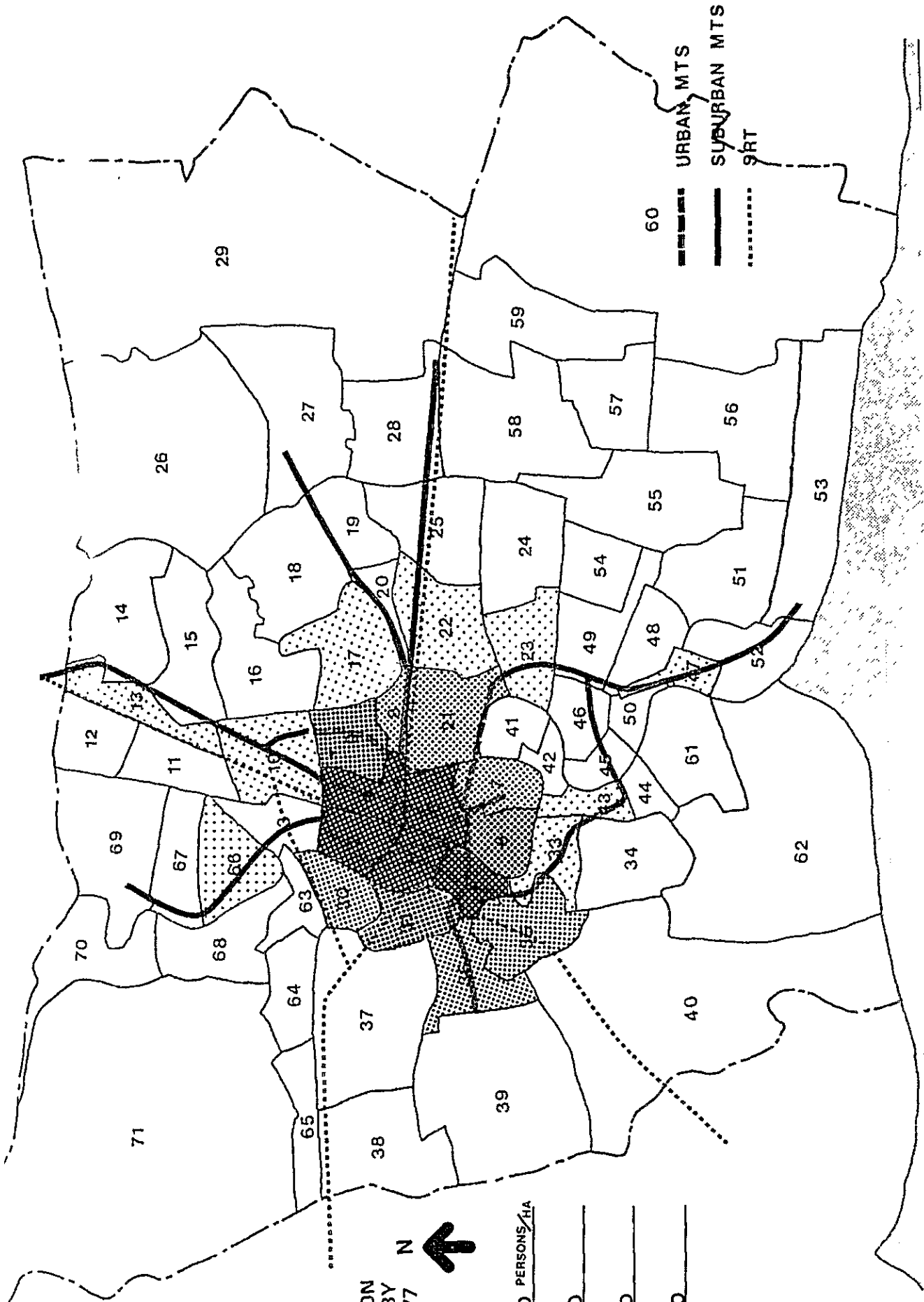
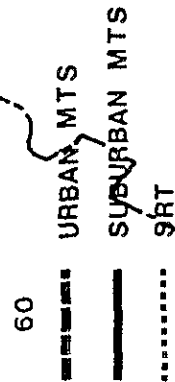
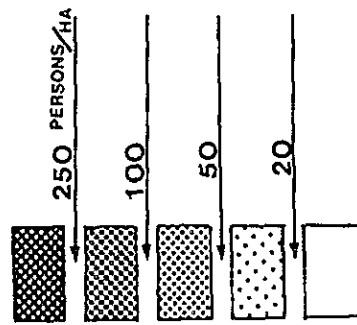
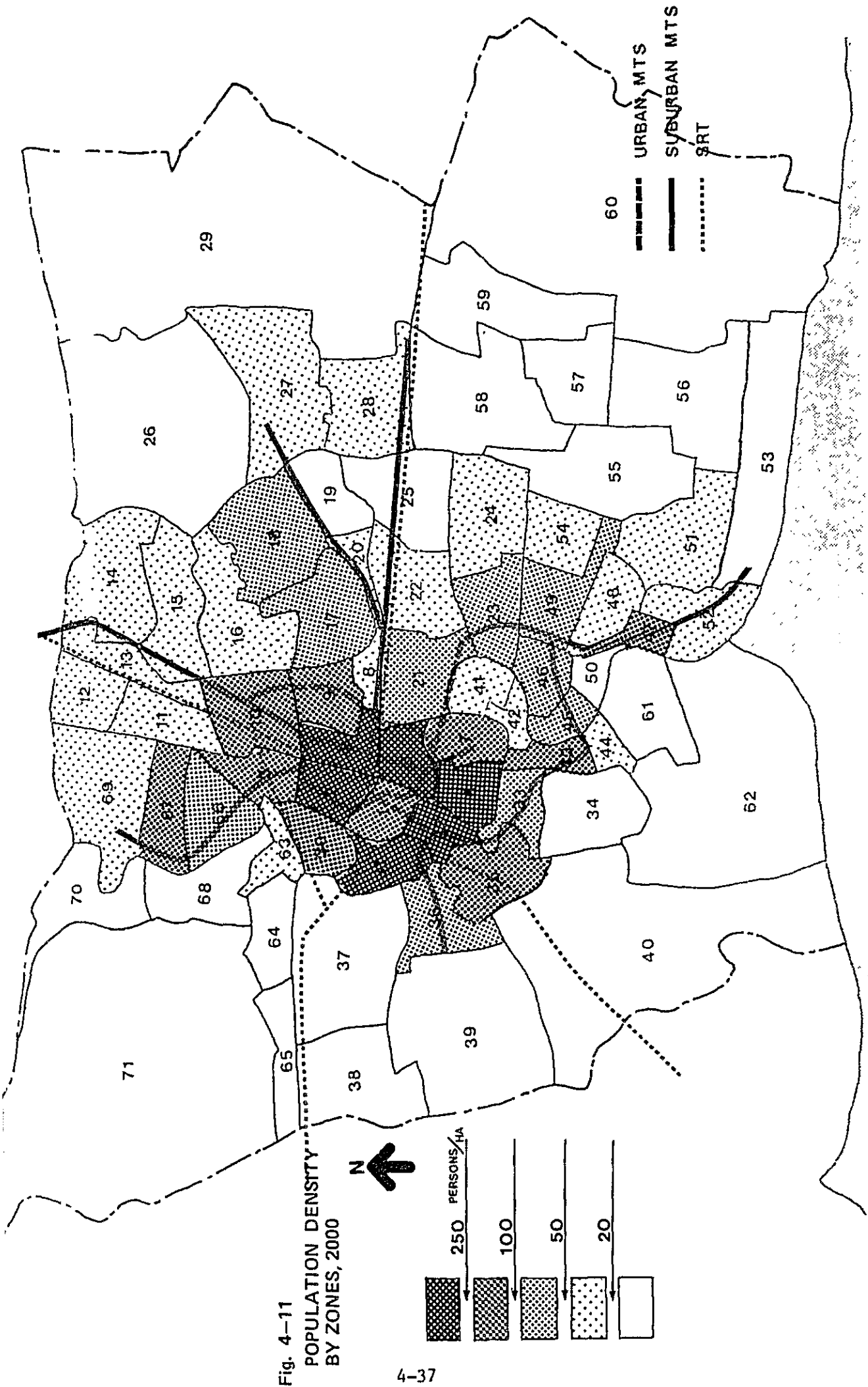


Fig. 4-10
POPULATION
DENSITY BY
ZONES, 1977





population is extrapolated by the Least Squares Method. The future zonal residential population is then adjusted by assuming the optimum population density in each zone.

For other zones in which changes in landuse is considered to be effective for allocation of population, a formula is developed to reflect the landuse pattern in each zone to the future zonal population. This formula is developed from the relationship between the area of each landuse item in each zone and the zonal population at present. Applying this formula to the future landuse in each zone, the future zonal population is calculated.

Also, the housing development projects of the National Housing Authority are assumed to be carried out as scheduled.

For zones outside Greater Bangkok the past development of the residential population is extrapolated into the future using the Least Squares Method, and then adjusted by the regional total in Section 4.2.1 "Residential Population".

4.4.3 Economically Active Population

(1) Sector I

The total economically active population in the primary sector in 1977 and 2000 is distributed over zones in proportion to the area of agricultural landuse in each zone. No commuting is assumed for the primary sector workers and the above figure is equal to the workers at work places in the primary sector.

(2) Sector II & Sector III

Applying the rate of employment in 1977 and 2000 to the zonal residential population in each year, the sum of the economically active population in the secondary and tertiary sectors in each zone is computed. Then, it is divided into the secondary and tertiary sectors by the average ratio for Greater Bangkok.

Table 4-22 AREA, RESIDENTIAL POPULATION & GROSS POPULATION DENSITY IN THE CENTRAL REGION OUTSIDE GREATER BANGKOK

Zone No.	Zone Name	Area (Km ²) ^{*-1}	1977		2000	
			Population (x1,000persons) ^{*-2}	Density (Persons/Ha)	Population (x1,000persons) ^{*-2}	Density (Persons/Ha)
72	Pathum Thani	149	59.2	3.9	63.6	4.3
73	Sam Khok	296	65.4	2.2	88.9	3.0
74	Khlong Luang	1,044	177.2	1.7	389.5	3.7
75	Suphanburi	4,826	784.6	1.6	1,110.9	2.3
76	Ayuthaya	2,494	615.2	2.5	859.6	3.5
77	Saraburi	3,356	454.0	1.4	680.1	2.0
78	Nakhon Nayok	2,414	196.1	0.8	273.5	1.1
79	Chachoengsao	889	177.6	2.0	298.5	3.4
80	Chonburi	1,113	321.0	2.9	563.4	5.1
81	Samut Sakhon	851	251.1	3.0	280.8	3.3
82	Nakhon Pathom	2,080	530.1	2.6	858.4	4.1
83	Ratchaburi	2,008	499.4	2.5	852.8	4.2
84	Samut Songkhram	18,035	1,004.9	0.6	1,731.1	1.0
85	Kanchanaburi	19,486	463.6	0.2	1,040.2	0.5
86	Lopburi	11,690	1,297.0	1.1	1,877.9	1.6
87	Prachinburi	2,693	585.3	2.2	1,235.8	4.6
88	Rayong	22,230	1,415.4	0.6	2,415.0	1.1
Total (Average)		95,654	8,301.1	(0.9)	14,620.0	(1.5)

Source *-1 Statistical Year Book of Thailand

*-2 Estimated by the Team.

4.4.4 Workers at Work Places

(1) Sector II

a) Workers at Work Places in Sector II

The secondary sector workers are not only in industrial areas, but also in other landuse areas. Especially in mixed-up high density areas, there are many small-scale home industry workshops. There are several industrial estates projects in progress by the Industrial Estate Authority of Thailand and among them those at Lat Krabang District and Bang Pu District^{*)22} are already approved and indicated on the DTCP map of land-use plan, and therefore, they have already been taken into consideration in zonal allocation of the future secondary sector workers.

Notes: ^{*) 22} In addition to these two projects the Industrial Estate Authority of Thailand is preparing the feasibility study for the industrial estate at Songkhla.

The total workers at work places in the secondary sector in 1977 and 2000 are divided into three portions for the purpose of their zonal allocation, and they are:

- The proportion to be allocated to the mixed-use high density area;
- The proportion to be allocated to the industrial area; and
- The proportion to be allocated to the residential population.

b) Workers at Work Places in Sector III

The tertiary sector work places are mostly massed in mixed-use high density areas and institutional areas. Generally, in the central district where government offices are largely concentrated, the density of workers in institutional areas is much higher than in institutional areas in the suburbs where schools and military bases are found. Therefore, the portion to be allocated to the institutional area is further divided into that for the "Central Business District"^{*)23} that for Zones #1, 2, 4 and 5, and that for the rest of Greater Bangkok. Consequently, the total workers at work places in the tertiary sector in 1977 and 2000 are divided into:

- The proportion to be allocated to the mixed-use high density area;
- The proportion to be allocated to the institutional areas (in the CBD and outside the CBD separately); and
- The proportion to be allocated to the residential population

Notes: ^{*)23} The term "Central Business District" might not be suitable in this case, because in this district not only is the density of workers high, but also the residential population is very high.

4.4.5 Traffic-Relevant Students

The total traffic-relevant students at present and in the future, estimated in Section 4.2.5 "Traffic-Relevant Students" are distributed over zones in proportion to the zonal residential population.

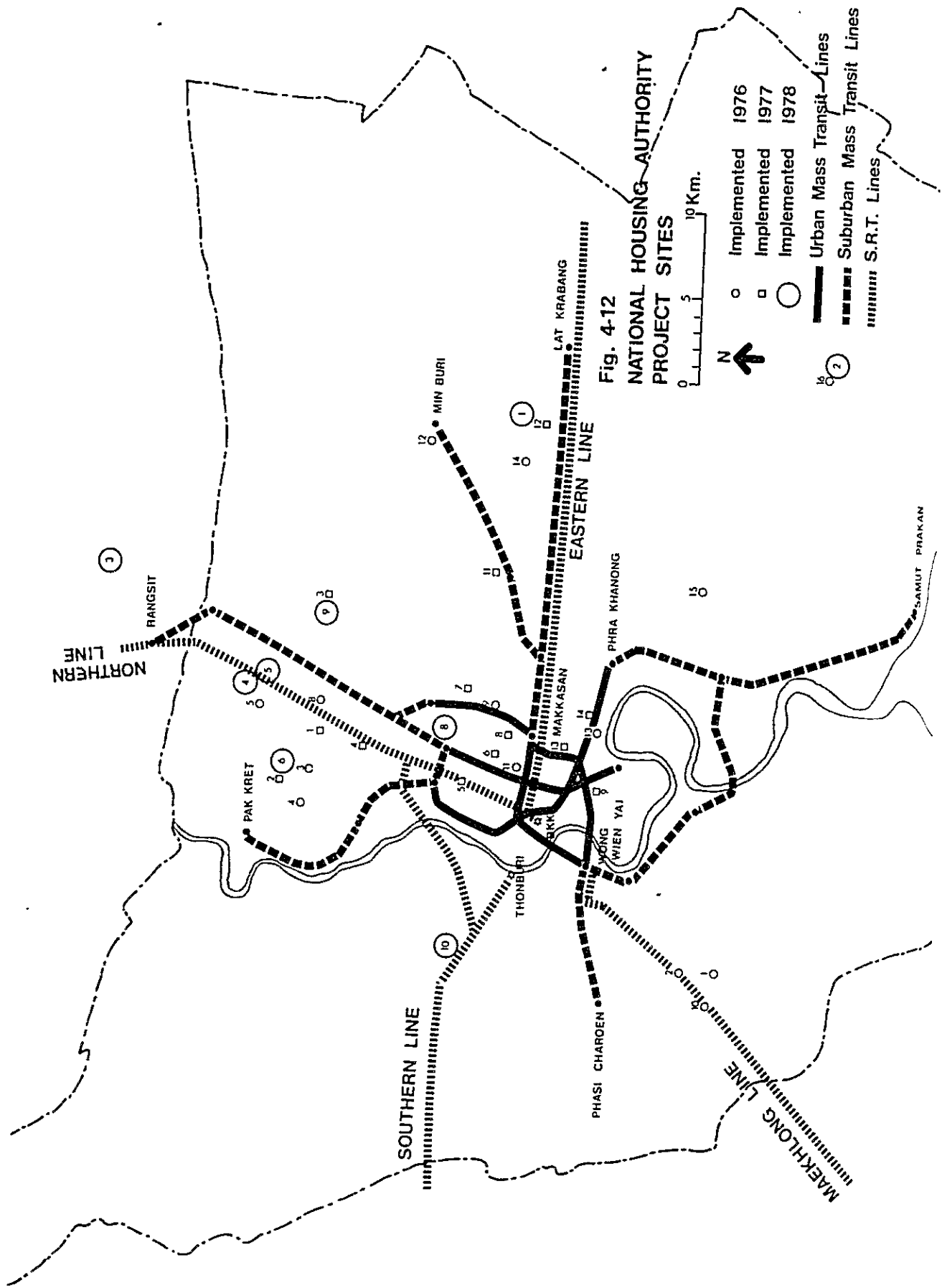


Fig. 4-12
NATIONAL HOUSING AUTHORITY
PROJECT SITES

- Implemented 1976
- Implemented 1977
- Implemented 1978
- Urban Mass Transit Lines
- - - Suburban Mass Transit Lines
- S.R.T. Lines

Table 4-24 RESIDENTIAL POPULATION, ECONOMICALLY ACTIVE POPULATION, WORKERS AT WORK PLACES & TRAFFIC RELEVANT STUDENTS, 1977

(Unit: 1,000 Persons)

Zone No.	Name of Zone	Residential Population	Gross Population Density (Persons/Ha)	Economically Active Population			Workers at Work Places		Traffic Relevant Students
				Sector I	Sector II	Sector III	Sector II	Sector III	
1	Phra Nakhon	406.9	548.4	-	32.8	65.4	21.8	83.9	16.7
2	Dusit	284.6	253.0	-	22.9	45.7	11.1	76.9	11.7
3	Bang Su	146.1	109.2	0.1	11.8	23.5	9.8	16.7	6.0
4	Phayathai	547.2	317.0	-	44.0	87.9	28.3	110.3	22.5
5	Pachuwat	349.9	288.9	-	28.2	56.2	19.1	91.9	14.4
6	Yannawa	257.7	130.6	0.2	20.7	41.4	20.2	44.2	10.6
7	Bang Pong Pang	110.6	73.8	0.2	8.9	17.8	11.5	19.4	4.5
8	Bang Kapi	24.6	24.2	0.1	2.0	4.0	2.4	6.2	1.0
9	Samsen	93.7	55.7	0.2	7.5	15.1	6.0	16.5	3.8
10	Lat Yao	142.6	42.0	-	11.5	22.9	29.1	22.8	5.8
11	Thung Song Hong	14.4	8.5	0.5	1.2	2.3	8.9	2.9	0.6
12	Thung Si Kan	26.2	12.7	1.0	2.1	4.2	1.0	2.2	1.1
13	Talat Bang Khen	42.5	26.4	-	3.4	6.8	6.6	6.3	1.7
14	Khlong Thanon	79.9	16.9	2.0	6.4	12.8	2.6	11.1	3.3
15	Thareng	36.5	11.1	0.5	2.9	5.9	2.1	2.3	1.5
16	Lat Phrao	33.7	10.0	1.2	2.7	5.4	1.3	2.0	1.4
17	Khlong Chan	69.7	22.8	0.9	5.6	11.2	4.7	8.9	2.9
18	Khlong Kum	32.9	8.0	2.0	2.6	5.3	5.5	3.2	1.3
19	Saphan Sung	9.0	5.7	0.9	0.7	1.4	0.2	0.4	0.4
20	Huamak	21.7	14.4	0.7	1.7	3.5	2.9	4.7	0.9
21	Phra Khanong	259.2	87.3	0.1	20.9	41.7	28.9	68.8	10.6
22	Suan Luang	50.0	22.1	1.0	4.0	8.0	2.5	6.1	2.1
23	Bang Na	119.5	40.2	0.8	9.6	19.2	17.8	16.6	4.9
24	Nong Bon	20.9	6.4	1.8	1.7	3.4	1.0	1.9	0.9
25	Prawet	24.8	6.5	1.9	2.0	4.0	6.8	1.2	1.0
26	Bang Chan	22.7	1.9	7.2	1.8	3.7	0.7	1.1	0.9
27	Minburi	25.7	4.1	3.6	2.1	4.1	2.9	2.4	1.1
28	Lat Krabang	20.7	4.8	2.4	1.7	3.3	1.4	5.1	0.9
29	Nong Chok	65.2	2.0	20.7	5.2	10.5	1.6	3.2	2.7
30	Bang O	126.4	88.5	0.1	10.2	20.3	7.0	21.6	5.2
31	Sirirat	341.9	206.3	0.2	27.5	54.9	18.6	60.5	14.0
32	Thonburi	390.4	268.1	-	31.4	62.7	23.6	64.0	16.0
33	Rat Burana	75.1	49.4	0.4	6.0	12.1	15.7	8.5	3.1
34	Thung Khru	23.3	7.5	1.8	1.9	3.8	0.8	1.9	1.0
35	Bang Khun Tian	123.4	56.3	1.0	9.9	19.8	9.2	15.8	5.1
36	Phasi Charoen	99.2	51.4	0.8	8.0	15.9	6.6	7.7	4.1
37	Taling Chan	47.0	9.1	3.1	3.8	7.6	1.7	3.0	1.9
38	Sala Than Masop	13.2	3.7	2.2	1.1	2.1	0.3	0.7	0.5
39	Nong Khaem	100.1	11.6	4.8	8.1	16.1	3.1	8.7	4.1
40	Bang Bon	59.9	9.8	7.9	4.8	9.6	3.9	3.0	2.5
	Bangkok Metropolis	4,739.0	30.5	72.3	361.3	761.5	341.2	837.6	194.7
41	Bang Ko Bua	15.2	14.3	0.5	1.2	2.4	2.0	0.8	0.6
42	Bang Yo	14.0	15.1	0.4	1.1	2.2	3.1	0.8	0.6
43	Bang Talat	40.9	43.9	0.2	3.3	6.6	11.3	10.2	1.7
44	Bang Chak	8.9	10.5	0.4	0.7	1.4	9.0	1.1	0.4
45	Bang Ya Phraek	16.5	16.5	0.4	1.3	2.7	5.7	2.8	0.7
46	Samrong Tai	29.7	26.7	0.3	2.4	4.8	24.8	2.9	1.2
47	Samut Prakan	48.4	50.8	0.3	4.0	7.8	5.0	12.0	2.0
48	Bang Huang	23.9	14.5	0.7	1.9	3.8	1.4	1.3	1.0
49	Samrong Nua	32.8	16.7	0.5	2.6	5.3	4.3	4.5	1.3
50	Bang Duan	11.1	13.6	0.3	0.9	1.8	0.4	0.7	0.4
51	Phraek Sa	6.6	1.5	2.6	0.5	1.1	0.3	0.3	0.3
52	Thai Ban	19.0	10.9	0.8	1.5	3.0	7.8	1.0	0.8
53	Bang Pumai	15.6	2.9	1.6	1.3	2.5	7.8	1.8	0.6
54	Bang Kaeo	8.5	3.3	1.6	0.7	1.4	0.3	0.4	0.3
55	Bang Phli Yai	13.8	2.9	2.8	1.1	2.2	0.6	1.0	0.6
56	Bang Pla	9.9	1.7	2.0	0.8	1.6	0.2	0.5	0.4
57	Bang Chalong	8.0	2.6	1.9	0.7	1.3	1.7	0.4	0.3
58	Racha Thewa	11.1	1.9	3.4	0.9	1.8	0.3	0.6	0.5
59	Srisa Charakhe	8.8	1.7	3.4	0.7	1.4	1.0	0.4	0.4
60	Bang Bo	72.5	2.5	18.4	5.9	11.6	2.3	4.6	3.0
61	Bang Pakok	22.8	8.5	1.5	1.8	3.7	6.8	1.8	0.9
62	Laem Fa Pha	27.6	2.4	7.1	2.2	4.4	1.1	3.6	1.1
	Samut Prakan	465.6	5.0	51.1	37.5	74.8	97.2	53.5	19.1
63	Wat Chalo	22.6	16.5	0.7	1.8	3.6	2.1	1.5	0.9
64	Bang Khanum	18.6	8.8	1.3	1.5	3.0	0.5	0.9	0.8
65	Bang Kruai	7.3	3.3	1.4	0.6	1.2	0.2	0.4	0.3
66	Nonthaburi	74.1	39.8	0.5	6.0	11.9	4.4	10.8	3.1
67	Bang Kraso	44.8	19.8	0.7	3.6	7.2	4.7	4.3	1.8
68	Bang Krang	29.5	8.9	2.0	2.4	4.7	1.0	2.4	1.2
69	Pak Kret	37.6	7.1	2.8	3.0	6.0	2.3	4.4	1.5
70	Om Kret	22.2	5.3	2.5	1.8	3.6	0.8	2.0	0.9
71	Bang Bua Thong	98.7	2.2	28.4	7.9	15.9	2.9	5.2	4.1
	Nonthaburi	355.4	5.3	40.3	28.6	57.1	23.9	31.9	14.6
	Greater Bangkok Area	5,560.0	17.6	163.7	447.4	893.4	462.3	923.0	228.4

Source: Estimated by the Team.

Table 4-25 RESIDENTIAL POPULATION, ECONOMICALLY ACTIVE POPULATION, WORKERS AT WORK PLACES & TRAFFIC RELEVANT STUDENTS, 2000

(Unit: 1,000 Persons)

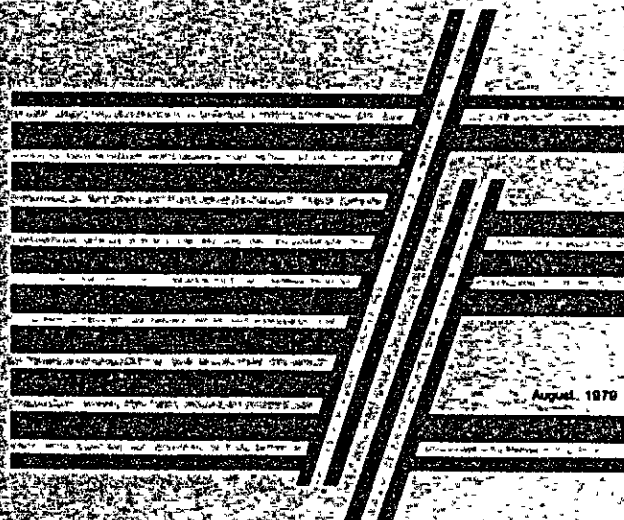
Zone No.	Name of Zone	Residential Population	Gross Population Density (Persons/Ha)	Economically Active Population			Workers at Work Places		Traffic Relevant Students
				Sector I	Sector II	Sector III	Sector II	Sector III	
1	Phra Nakhon	273.0	233.7	-	29.2	55.0	20.2	68.4	35.8
2	Dusit	325.4	289.2	-	34.8	65.6	21.4	85.1	42.7
3	Bang Su	136.9	102.3	-	14.6	27.6	9.6	12.3	18.0
4	Phayathai	705.5	408.7	-	75.4	142.2	58.0	174.3	92.7
5	Pathumwan	395.3	326.4	-	42.2	79.7	31.7	105.8	51.9
6	Yannawa	492.4	364.2	-	52.6	99.2	32.5	68.3	64.7
7	Bang Pong Pang	247.6	165.3	-	26.4	49.9	18.6	46.5	32.5
8	Bang Kapi	28.7	48.2	-	3.1	5.8	6.7	25.3	3.8
9	Samsen	416.4	247.6	-	44.5	83.9	37.5	102.5	54.6
10	Lat Yao	497.2	146.6	-	53.1	100.2	54.3	130.4	65.3
11	Thung Song Hong	47.5	28.0	-	5.1	9.6	2.6	8.5	6.2
12	Thung Si Kan	42.9	20.8	0.2	4.6	8.6	2.4	3.8	5.6
13	Talat Bang Khen	78.6	48.8	0.1	8.4	15.8	9.6	18.1	10.3
14	Khlong Thanon	131.3	27.7	0.9	14.0	26.5	12.7	38.8	17.2
15	Thareng	119.2	36.1	0.3	12.7	24.0	6.5	19.8	15.6
16	Lat Phrao	107.7	32.0	0.9	11.5	21.7	8.9	23.2	14.1
17	Khlong Chan	191.4	62.6	-	20.4	38.6	16.0	41.6	25.1
18	Khlong Kum	321.0	78.0	-	34.3	64.7	30.5	74.3	42.1
19	Saphan Sung	30.3	19.1	-	3.2	6.1	1.7	2.7	4.0
20	Huamak	53.3	35.4	-	5.7	10.7	2.9	6.4	7.0
21	Phra Khanong	285.2	96.1	-	30.5	57.5	50.5	103.9	37.4
22	Suan Luang	95.5	42.3	-	10.2	19.2	5.2	8.5	12.5
23	Bang Na	175.4	59.1	-	18.7	35.3	35.4	36.2	23.0
24	Nong Bon	153.4	47.0	-	16.4	30.9	12.9	33.7	20.1
25	Pravet	49.3	12.8	-	5.3	9.9	2.7	4.4	6.5
26	Bang Chan	36.5	3.0	3.4	3.9	7.4	2.0	3.3	4.8
27	Minburi	282.4	45.3	1.1	30.2	56.9	29.8	66.6	37.0
28	Lat Krabang	167.3	39.1	0.9	17.9	33.7	13.3	30.7	21.9
29	Nong Chok	100.5	3.1	9.0	10.7	20.3	39.6	9.0	13.2
30	Bang O	215.6	150.8	-	23.0	43.4	13.1	51.3	28.3
31	Sirirat	520.5	314.1	-	55.6	104.9	40.6	101.6	68.3
32	Thonburi	361.3	248.1	-	38.6	72.8	33.5	93.3	47.4
33	Rat Burana	146.0	96.1	-	15.6	29.4	11.3	27.8	19.2
34	Thung Khru	59.8	19.2	-	6.4	12.0	4.2	10.0	7.8
35	Bang Khun Tian	309.8	141.3	0.1	33.1	62.4	21.7	48.4	40.6
36	Phasi Charoen	154.8	80.2	0.1	16.5	31.2	8.7	14.9	20.3
37	Taling Chan	55.9	10.8	1.2	6.0	11.3	3.1	5.0	7.3
38	Sala Than Masop	27.6	7.7	1.1	2.9	5.6	1.5	2.5	3.6
39	Nong Khaem	159.3	18.5	2.0	17.0	32.1	10.4	21.8	20.9
40	Bang Bon	58.2	4.6	3.3	6.2	11.7	3.2	5.2	7.6
	Bangkok Metropolis	8,055.9	51.8	24.6	860.5	1,623.3	733.0	1,734.2	1,056.9
41	Bang Ko Bua	21.7	20.4	-	2.3	4.4	1.2	1.9	2.8
42	Bang Yo	42.0	45.3	-	4.5	8.5	3.2	7.7	5.5
43	Bang Talat	173.3	186.1	-	18.6	34.9	26.2	42.3	22.7
44	Bang Chak	19.0	22.4	-	2.0	3.8	21.1	1.7	2.5
45	Bang Ya Phraek	74.2	74.3	-	7.9	15.0	19.8	15.9	9.7
46	Samrong Tai	61.1	54.9	-	6.5	12.3	48.7	5.5	8.0
47	Samut Prakan	218.4	229.4	-	23.4	43.4	19.9	54.7	28.7
48	Bang Muang	68.0	41.3	-	7.3	13.7	5.5	12.2	8.9
49	Samrong Nua	98.3	50.2	-	10.5	19.8	16.1	19.0	12.9
50	Bang Duan	15.1	18.4	-	1.6	3.0	2.5	1.6	2.0
51	Phraek Sa	93.1	21.4	-	9.9	18.8	11.6	8.3	12.2
52	Thai Ban	37.0	21.2	-	4.0	7.5	33.9	3.3	4.9
53	Bang Pumai	35.3	6.6	0.5	3.8	7.1	42.0	3.2	4.6
54	Bang Kaeo	53.4	20.7	0.2	5.7	10.8	3.2	6.0	7.0
55	Bang Phli Yai	13.2	2.7	1.4	1.4	2.7	0.7	1.2	1.7
56	Bang Pla	12.6	2.2	1.7	1.3	2.5	0.7	1.1	1.7
57	Bang Chalong	8.8	2.8	0.9	0.9	1.8	0.8	0.8	1.2
58	Racha Thewa	89.7	15.3	0.8	9.6	18.1	31.7	13.0	11.8
59	Srisa Charakhe	14.7	2.8	1.5	1.6	3.0	0.8	1.3	1.9
60	Bang Bo	99.8	3.4	8.6	10.7	20.1	5.5	8.9	13.1
61	Bang Pakok	53.3	19.9	-	5.7	10.7	25.7	4.8	7.0
62	Laem Fa Pha	31.3	2.7	3.3	3.3	6.3	1.7	2.8	4.1
	Samut Prakan	1,333.3	14.3	18.9	142.5	268.7	322.5	217.2	174.9
63	Wat Chalo	31.1	22.7	-	3.3	6.3	3.4	2.8	4.1
64	Bang Khanum	26.8	12.7	0.5	2.9	5.4	1.5	2.4	3.5
65	Bang Kruai	7.4	3.4	0.7	0.8	1.5	0.4	0.7	1.0
66	Nonthaburi	116.9	62.7	-	12.5	23.6	9.7	34.8	15.3
67	Bang Kraso	297.0	131.6	-	31.7	59.8	25.1	68.4	39.0
68	Bang Krang	44.7	13.5	0.4	4.8	9.0	2.5	4.0	5.9
69	Pak Kret	117.2	22.1	0.4	12.5	23.6	8.0	23.3	15.4
70	Om Kret	10.0	2.4	1.2	1.1	2.0	0.5	0.9	1.3
71	Bang Bua Thong	69.7	1.5	13.3	7.4	14.0	3.8	6.2	9.1
	Nonthaburi	720.8	10.7	16.5	77.0	145.2	54.9	143.5	94.6
	Greater Bangkok Area	10,110.0	31.9	60.0	1,080.0	2,037.2	1,110.4	2,094.9	1,326.4

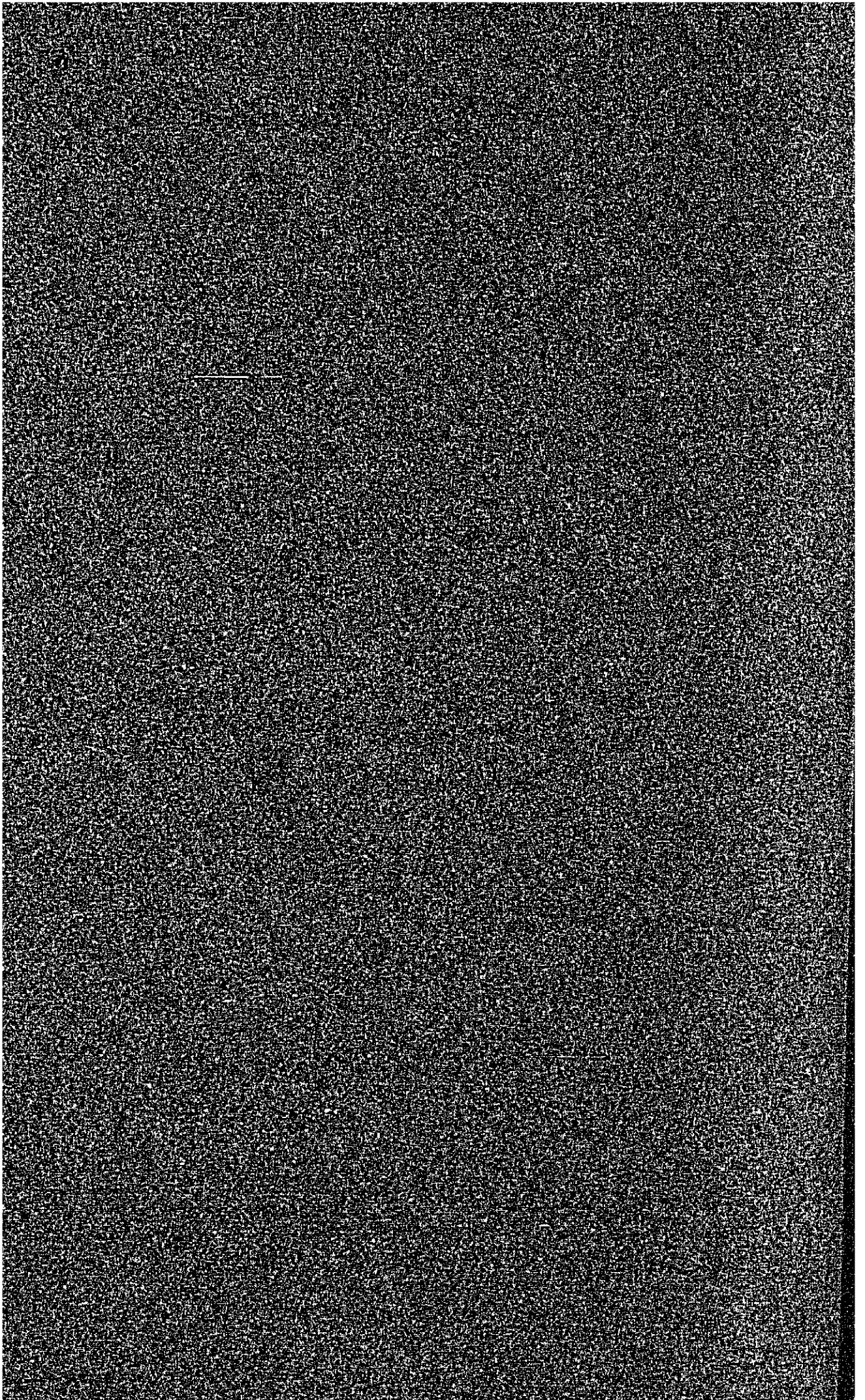
Source: Estimated by the Team.

CHAPTER 5

TRANSPORTATION PLANNING AND FORECASTS OF FUTURE TRAFFIC DEMAND

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Chapter 5 TRANSPORTATION PLANNING AND FORECASTS OF FUTURE TRAFFIC DEMAND

In this chapter, the Mass Transit System in the Bangkok suburban area and the function of railway for commuting passengers were examined based on the basic concept of the future land use plan examined in the Chapter 4.

5.1 Forecasts of Traffic Demand

5.1.1 Outline of Forecasting Method

The greatest demand period for the transport network which causes it to become most congested is that during peak hours. For the purpose of determining the policy of transport facilities, future traffic demand in the peak period will be forecast as a key factor.

In the Bangkok area, the congested conditions of existing traffic demand and the growth of future urbanization, make consideration of the demand in the peak period all the more necessary. For the forecasting of future traffic demand in the project area, future person-trip demand in the peak hours are examined along with future truck traffic demand in the same period. The methodological flow chart for estimation of future traffic volume is as shown in Fig. 5-1.

5.1.2 Forecast of Person-Trips

In this paragraph, existing and future number of generated and attracted person-trips by zones are forecasted based on the residential population, economically active population, workers at work places and the number of students.

(1) Trip Purpose

For the estimation of future person trip demand on the peak period, the concept of trip "purpose" is important, since different trip purposes are associated not only with different trip generation rates but also with different trip distribution and modal split characteristics. In this study, a typical classification of the trip purpose is 'going to work', 'going to school' and others. This classification was applied for the reason of limitation of estimation precision. Trips were assumed to mainly consist of these trip purposes in the peak period.

(2) Establishment of Present Person Trip O-D Table, 1977

a) Ratio of Intrazonal Trips

According to the present person trip O-D matrices, 1972, surveyed in the Bangkok Transportation Study, intrazonal trip rate for different trip purposes and modal splits are as shown in Table 5-1.

Table 5-1 INTRAZONAL TRIP RATIO

(Unit: Persons/day)

Trip Purpose	Modal Split	Generated and Attracted Trips	Intrazonal Trips	Ratio of Intrazonal Trips
School Trips	Taxi Samlo	21,988	9,892	45.0 %
	Public Bus	258,217	90,317	35.0
	Car Motorcycle	58,338	15,083	25.9
	Total	338,543	115,292	34.1
Other Trips	Taxi Samlo	642,734	230,273	35.8
	Public Bus	2,199,576	603,054	27.4
	Car Motorcycle	1,306,697	166,754	12.8
	Total	4,149,007	1,000,081	24.1
Total	Taxi Samlo	664,722	240,165	36.1
	Public Bus	2,457,793	693,373	28.2
	Car Motorcycle	1,365,035	181,837	13.3
	Total	4,487,550	1,115,373	24.9

Source: Person Trips O-D matrices, 1972, BTS

This table shows that the intrazonal trip rate of school trips is about 34 percent and "Other Trips" including work trips is about 24 percent. These figures are a bit small compared with a general concept of the purpose of person trip but these figures consist of the survey results of persons who made a trip in a vehicle, of course excluding walking persons who mostly made intrazonal trips.

i) Work trips

Based on the survey results of the Bangkok Transportation Study, 1972, the ratio of intrazonal work trips is established by the following process. It is determined by the consideration of the survey results (i.e., "More than 30 percent of all employees had their work place at home"), the intrazonal trip ratio (as mentioned in the above table 5-1) and a ratio of economically active population by sector classification in 1977. The economically active population in 1977 by sector classification is as shown in Table 5-2.

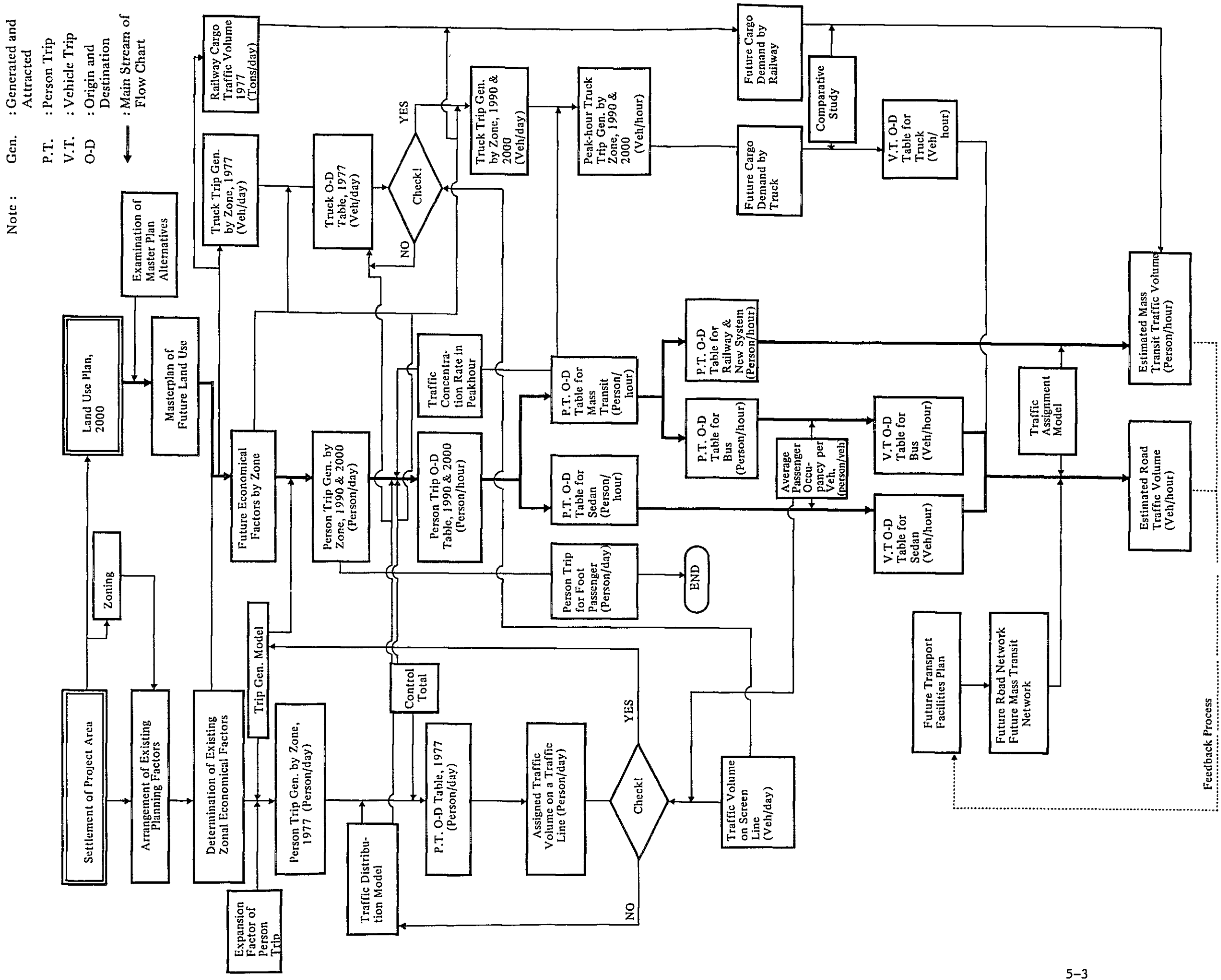
Table 5-2 ECONOMICALLY ACTIVE POPULATION BY SECTOR, 1977

(Unit: 1,000 persons)

Sector	Economically Active Population	Sector Composition (%)
I	163.7	10.6
II	456.5	29.4
III	930.2	60.0
Total	1,550.4	100.0

Source: Estimated by the Team in Chapter 4

Fig. 5-1 METHODOLOGICAL FLOW CHART FOR ESTIMATION OF FUTURE TRAFFIC VOLUME



1. The first part of the document is a list of names and addresses.

2. The second part is a list of names and addresses.

3. The third part is a list of names and addresses.

4. The fourth part is a list of names and addresses.

5. The fifth part is a list of names and addresses.

6. The sixth part is a list of names and addresses.

7. The seventh part is a list of names and addresses.

8. The eighth part is a list of names and addresses.

9. The ninth part is a list of names and addresses.

10. The tenth part is a list of names and addresses.

11. The eleventh part is a list of names and addresses.

12. The twelfth part is a list of names and addresses.

13. The thirteenth part is a list of names and addresses.

14. The fourteenth part is a list of names and addresses.

15. The fifteenth part is a list of names and addresses.

16. The sixteenth part is a list of names and addresses.

Therefore, the equation for the ratio of intrazonal work trips can be defined as follows:

$$R.I.T. = a[b + 0.24 (1-b)] \times 100$$

where: R.I.T. : Ratio of intrazonal work trips

a: Sector composition of economically active population (Sector II + III)

b: The ratio of employees who has their work place at home

Using this equation, the ratio of intrazonal work trips is calculated as follows:

$$\begin{aligned} R.I.T. &= 0.894 [0.3 + 0.24 (1-0.3)] \times 100 (\%) \\ &= 41.8\% \end{aligned}$$

The survey result of intrazonal trip ratio of person trips excluding school trips is 24 percent but this figure including the other purpose trips such as shopping trips. Therefore, the actual intrazonal trip ratio for work trips should be lower. As a consequence of this consideration, the ratio of work trips is established as 40 percent. Although, the intrazonal person trip ratio will show a general tendency to decrease in future through the improvement of the transportation infrastructure, the tendency of bringing one's residence and place of work close together will increase. It is very difficult to make a sweeping generalization. Accordingly, the ratio of intrazonal trips in the future is assumed to be similar to the present condition.

ii) School trips

Generally, the trip distance of school trips has a tendency to be shorter than the trip distance of work trips.

The average intrazonal trip ratio of school trips in the survey result 1972 was approximately 35 percent, including the school trips of elementary school student and junior high school student who usually consists of comparatively short distance trips. However, the results consist of only those persons who made a trip in a vehicle. Therefore, in this study, the survey results were adopted.

b) Estimation of Generated and Attracted Commuter Person Trips

Based on the estimated results of number of workers and students by zone and the intrazonal trip ratio established in the previous paragraph, generated and attracted commuter person trips for each zones was determined by the following procedure:

- Step ① Sum the total of economically active population in the zone who are engaged in secondary and tertiary sectors.
- ② Sum the total of number of workers who are working in the zone and engaged in secondary and tertiary sectors.
- ③ Calculate the intrazonal commuting persons in the zone who are engaged in secondary and tertiary sectors.
- ④ Interzonal commuting person in the zone who are engaged in secondary and tertiary sectors and generated from the zone: (① - ③)
- ⑤ Interzonal commuting person in the zone who are engaged in secondary and tertiary sectors and attracted to the zone: (② - ③)
- ⑥ Generated and attracted number of student, multiplying number of student by ratio of interzonal student trips.
- ⑦ Generated commuter person trips: (④ + ⑥)
- ⑧ Attracted commuter person trips: (⑤ + ⑥)

Thus, the generated and attracted interzonal commuting person trips by zone are estimated. The result is summarized as shown in Table 5-3 and the result by zone is shown in Table 5-4.

Table 5-3 SUMMARY OF THE GENERATED AND ATTRACTED
COMMUTER PERSON TRIPS, 1977

(Unit: 1,000 persons/day)

Area	To Work			To School	Commuting Person Trips		
	Generated Person-Trips	Attracted Person-Trips	Total Trip Ends	Generated & Attracted Person-Trips	Generated Person-Trips	Attracted Person-Trips	Total Trip Ends
Bangkok Metropolis	746.0 (84.0)	749.6 (83.3)	1,495.6 (83.6)	126.9 (85.1)	872.9 (84.2)	876.5 (83.5)	1,749.4 (83.9)
Samut Prakan	77.8 (8.8)	116.2 (12.9)	194.0 (10.9)	12.7 (8.5)	90.5 (8.7)	128.9 (12.3)	219.4 (10.5)
Nonthaburi	64.5 (7.2)	34.6 (3.8)	99.1 (5.5)	9.6 (6.4)	73.1 (7.1)	44.2 (4.2)	117.3 (5.6)
Total GBA	888.3 (100.0)	900.4 (100.0)	1,788.7 (100.0)	149.2 (100.0)	1,036.5 (100.0)	1,049.6 (100.0)	2,086.1 (100.0)

Source: Estimated by the Team

Note : The figures in the parenthesis show the percentage.

Table 5-4 GENERATED AND ATTRACTED COMMUTING PERSON TRIP, 1977

(Unit: 1,000 persons/day)

Zone No	Trip Purpose	To Work			To School	Total Commuting Person Trip		
		Generated	Attracted	Total		Generated	Attracted	Total
1		58.9	66.4	125.3	10.9	69.8	77.3	147.1
2		41.2	60.6	101.8	7.6	48.8	68.2	117.0
3		24.7	1.8	26.5	3.9	28.6	5.7	34.3
4		79.1	85.8	164.9	14.6	93.7	100.4	194.1
5		50.6	77.2	127.8	9.4	60.0	86.6	146.6
6		37.3	39.6	76.9	6.9	44.2	46.5	90.7
7		16.0	20.2	36.2	2.9	18.9	23.1	42.0
8		3.6	6.2	9.8	0.7	4.3	6.9	11.2
9		13.6	13.5	27.1	2.5	16.1	16.0	32.1
10		20.6	38.1	58.7	3.8	24.4	41.9	66.3
11		2.1	2.4	4.5	0.4	2.5	2.8	5.3
12		5.0	1.9	6.9	0.7	5.7	2.6	8.3
13		6.1	8.8	14.9	1.1	7.2	9.9	17.1
14		13.7	8.2	21.9	2.1	15.8	10.3	26.1
15		5.3	5.9	11.2	1.0	6.3	6.9	13.2
16		6.8	2.0	8.8	0.9	7.7	2.9	10.6
17		11.4	8.2	19.6	1.9	13.3	10.1	23.4
18		4.7	5.2	9.9	0.8	5.5	6.0	11.5
19		1.9	0.4	2.3	0.3	2.2	0.7	2.9
20		3.1	5.5	8.6	0.6	3.7	6.1	9.8
21		37.6	72.7	110.3	6.9	44.5	79.6	124.1
22		7.2	3.8	11.0	1.4	8.6	5.2	13.8
23		17.3	22.9	40.2	3.2	20.5	26.1	46.6
24		3.1	1.7	5.6	0.6	4.5	2.3	6.8
25		3.6	5.6	9.2	0.7	4.3	6.3	10.6
26		4.8	1.1	5.9	0.6	5.4	1.7	7.1
27		4.1	3.2	7.3	0.7	4.8	3.9	8.7
28		3.2	3.7	6.9	0.6	3.8	4.3	8.1
29		13.8	2.9	16.7	1.8	15.6	4.7	20.3
30		19.1	17.2	36.3	3.4	22.5	20.6	43.1
31		50.8	47.5	98.3	9.1	59.9	56.6	116.5
32		59.1	52.6	111.7	10.4	69.5	63.0	132.5
33		10.9	17.0	27.9	2.0	12.9	19.0	31.9
34		4.6	1.6	6.2	0.7	5.3	2.3	7.6
35		28.7	15.0	43.7	3.3	32.0	18.3	50.3
36		28.2	8.6	36.8	2.7	30.9	11.3	42.2
37		9.5	2.8	12.3	1.2	10.7	4.0	14.7
38		2.8	0.6	3.4	0.3	3.1	0.9	4.0
39		19.5	7.1	26.6	2.7	23.2	9.8	32.0
40		11.6	4.1	15.7	1.6	13.2	5.7	18.9
Bangkok Metropolis		746.0	749.6	1,495.6	126.9	872.9	876.5	1,749.4
41		2.5	1.7	4.2	0.4	2.9	2.1	5.0
42		2.0	2.6	4.6	0.4	2.4	3.0	5.4
43		5.9	17.5	23.4	1.1	7.0	18.6	25.6
44		1.3	9.3	10.6	0.3	1.6	9.6	11.2
45		2.4	6.9	9.3	0.5	2.9	7.4	10.3
46		4.3	24.8	29.1	0.8	5.1	25.6	30.7
47		7.1	12.3	19.4	1.3	8.4	13.6	22.0
48		4.6	1.6	6.2	0.7	5.3	2.3	7.6
49		4.7	5.6	10.3	0.8	5.5	6.4	11.9
50		2.3	0.7	3.0	0.3	2.6	1.0	3.6
51		1.4	0.4	1.8	0.2	1.6	0.6	2.2
52		2.7	7.0	9.7	0.5	3.2	7.5	10.7
53		2.3	8.1	10.4	0.4	2.7	8.5	11.2
54		1.8	0.4	2.2	0.2	2.0	0.6	2.6
55		2.7	1.0	3.7	0.4	3.1	1.4	4.5
56		2.1	0.4	2.5	0.3	2.4	0.7	3.1
57		1.2	1.3	2.5	0.2	1.4	1.5	2.9
58		2.3	0.5	2.8	0.3	2.6	0.8	3.4
59		1.5	0.8	2.3	0.3	1.8	1.1	2.9
60		14.7	4.1	18.8	2.0	16.7	6.1	22.8
61		3.3	6.4	9.7	0.6	3.9	7.0	10.9
62		4.7	2.8	7.5	0.7	5.4	3.5	8.9
Samut Prakan		77.8	116.2	194.0	12.7	90.5	128.9	219.4
63		4.0	2.2	6.2	0.6	4.6	2.8	7.4
64		3.9	0.8	4.7	0.5	4.4	1.3	5.7
65		1.6	0.4	2.0	0.2	1.8	0.6	2.4
66		11.8	9.1	20.9	2.0	12.8	11.1	23.9
67		7.2	5.4	12.6	1.2	8.4	6.6	15.0
68		5.7	2.0	7.7	0.8	6.5	2.8	9.3
69		5.4	8.1	13.5	1.0	6.4	9.1	15.5
70		4.3	1.7	6.0	0.6	4.9	2.3	7.2
71		20.6	4.9	25.5	2.7	23.3	7.6	30.9
Nonthaburi		64.5	34.6	99.1	9.6	73.1	44.2	117.3
Greater Bangkok Area		888.3	900.4	1,788.7	149.2	1,036.5	1,049.6	2,086.1

Source: Estimated by the Team

c) Person Trips for All Purposes

According to the O-D survey result in 1972, the proportion of commuter trips in the total trips were determined. The "Bangkok Transportation Study" report shows the following results.

- ① GBA Generated and attracted number of person-trips: 4,678 thousand/day
- ② GBA Generated and attracted number of person-trips for commuters: 2,200 thousand/day
- ③ All purposes expansion rate: $4,678/2,200 = 2.126$

Using the expansion rate, the generated and attracted person trips for all purposes was calculated. In this study, it is assumed this expansion rate is the same for all zones.

d) Estimation of Distributed Traffic Volume

i) Traffic distribution model

Up to the present, many traffic distribution models have been developed and used. According to the future plan of Greater Bangkok Area and surroundings, improvement of infrastructure, especially those parts of the road network, such as the Expressway, the Outer Bangkok Ring Road and urban planning road, will exert a large influence on the traffic flow pattern. The First Stage Mass Transit System will also exert a large influence, especially person trip flow patterns. The traffic distribution model needs to be able to take account of these various factors affecting the pattern of traffic flow in order to simulate actual conditions, particularly the time distance between zones.

In this study, based on these considerations, the "gravity model" was chosen. The parameters of the model were determined as follows from the analysis of the present O-D matrices of Thailand.

"Gravity Model"

$$T_{ij} = T_i \times T_j \times \frac{k}{D_{ij}^n}$$

where T_{ij} : Distributed trip volume between zone i and j

T_i : Generated (Attracted) trip volume of zone i

T_j : Generated (Attracted) trip volume of zone j

D_{ij} : Required travel time between zone i and zone j

n and k : Coefficients

Parameters were calculated to be as follows:

	Person-Trip	Truck Trip
n	1.329	1.736
k	0.158	0.447

Source: Correlation analysis of the present O-D matrices

The established O-D matrices for 1977 are shown separately.

ii) Evaluation of the established O-D matrices

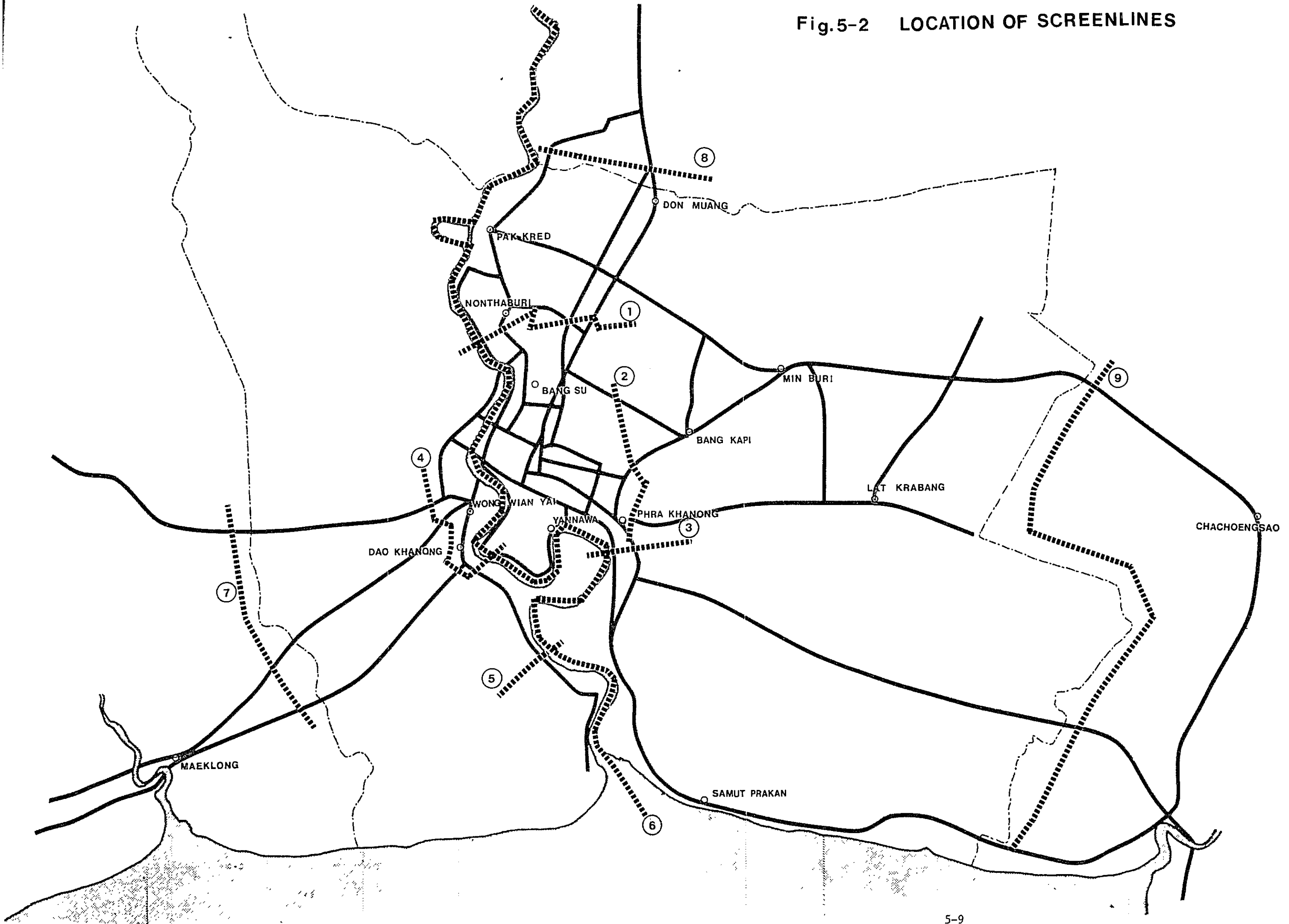
For the purpose of checking the accuracy of the established O-D matrices, the total traffic volume observed crossing screenlines was compared with the estimated traffic volume obtained from the traffic model.

In the GBA and on the boundary of GBA, 9 screenlines were selected as Fig. 5-2. Since the established O-D matrix unit was the person-trip, the actual vehicle traffic volume on the road was translated to the person-trip volume using the following passenger occupancy rates established in Chapter 4.

Car & Taxi : 1.75 persons/vehicle
Light Bus : 4.50 persons/vehicle
Heavy Bus : 20.00 persons/vehicle

The results of comparing the observed crossing the screenline person-trip volume and the estimated person-trip volume is shown in Table 5-5. The amount of the assigned flows on the selected screenlines was 1,744,849 persons/day which was almost the same as the observed flow: 1,711,423. The result indicates the adjustment ratio, which means the ratio of observed person-trips on the screenline to estimated person-trip on it, should be 0.98. Generally, the observed flows on the screenline should be higher than the estimated flows for the reason that the observed person-trips include the intrazonal person-trips which could not be assigned to the road network. The explanation for an adjustment ratio under 1.0 in this case, probably was because observed flows excluded the traffic flows of motorcycles and samllors. Based on these considerations, it was decided that the method and models which are used in this study for establish the O-D matrices are valid. Accordingly, the same method and models are adopted for the establishment of future O-D matrices.

Fig.5-2 LOCATION OF SCREENLINES



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Table 5-5 VERIFYING PERSON-TRIPS ON THE SCREENLINE

Screen Line No.	(A) Cross-sectional Traffic Volume (veh/day)	(B) Converted Person Trips (persons/day)	(C) Assigned Person Trips (persons/day)	(B)/(C) Adjustment Ratio	(B)/(A) Average Occupancy (persons/veh)
1	64,270	275,795	241,555	1.14	4.3
2	29,016	110,846	94,495	1.17	3.8
3	56,954	185,879	220,430	0.84	3.3
4	31,580	150,399	172,001	0.87	4.8
5	18,851	49,555	56,812	0.87	2.6
6	197,365	706,244	715,161	0.99	3.6
7	22,839	63,860	73,095	0.87	2.8
8	24,096	122,532	126,101	0.97	5.1
9	10,329	46,313	45,199	1.02	4.5
Total	455,300	1,711,423	1,744,849	0.98	3.8

(3) Establishment of Future O-D Matrices

For the purpose of examining the master-plan of Suburban Mass Transit System, the peak demand has been considered. Since the greatest demand for the transport network and the cause of the most congestion is during the peak hours; the design of transport facilities of the suburban mass transit, should be based on it. At this stage, both the established person-trip O-D matrices and commercial vehicle trip O-D matrices for peak hours using the future indices established in Chapter 4 and the same method which was established previous paragraph to calculate the generated and attracted traffic were adopted.

For the establishment of future peak hour O-D matrices, the trip purpose during peak period is considered. Accordingly the establishment of future O-D matrices are mainly based on the work trip and school trips during the peak hour.

a) Traffic Concentration Ratio in Peak-Hours

The concentration of commuter traffic was studied in the peak-three-hour period (06.00 ~ 09.00 hours) and the maximum peak hour. Table 5-6 shows the survey results of the "Bangkok Transportation Study".

Table 5-6 PERSON-TRIP CONCENTRATION RATIO

(Unit: %)

Trip Purpose	Item	Concentration Ratio for Peak-Three-hour Period	Maximum Concentration Ratio in Peak-Three-Hour	Trip Concentration Ratio in Peak Hour
	Period	6:00 ~ 9:00	7:00 ~ 8:00	7:00 ~ 8:00
To School		92.4	41.3	38.0
To Work		65.0	39.4	25.0

Source: BTS, 1972

i) School trips

Based on the above survey results, the peak-3-hour school trips account for 92.4 percent of the total daily school trips, and the maximum hour (07.00 - 08.00) school trips account for 41.3 percent of the peak-3-hour school trips. Therefore, school trip concentration ratio in peak hour was conservatively set as 38 percent.

ii) Work trips

The work trips concentration ratio in peak-3-hour period account for 65 percent of the total daily work trips and the maximum hour (07.00 - 08.00) work trips account for 39.4 percent. Accordingly, work trip concentration ratio in peak hour was conservatively set at 25 percent.

b) Expansion Ratio for All Purposes in the Peak-Hour

The proportion of commuter trips made for all purposes during the peak-hours is fixed by the expansion ratio. According to the survey result of BTS, the occupancy ratio of work trips and school trips in the peak period between 6 and 9 a.m., are as follows:

• Work Trips	52%
• School Trips	29%
<hr/>	
Sub Total	81%
• Other Trips	19%
<hr/>	
Total	100%

The maximum peak hour is between 7 and 8 a.m. and the trip occupancy ratio of work and school trips in this hour will more higher than the ratio between 6 and 9 a.m. Further, as the activities in the urban communities will be increasing in future, the trip concentration ratio of this trip purposes in the peak hour also will increase. In this study, based on the above considerations, the occupancy ratio of work and school trips for all trips in future are assumed as 90 percent. Consequently, the expansion ratio for all purposes in the peak hour is calculated as 1.111.

c) Revision by the Workday Ratio

The workday ratio is the number of actual workdays over the potential workdays per annum excluding Sundays and national holidays.

The workday ratio was calculated using the following assumption:

Sundays	52 days/year
National holidays	15 days/year
<hr/>	
Total holidays	67 days/year
Potential workdays	365-67 = 298 days/year
Paid leave	15/298 = 0.05
Workday ratio	1-0.05 = 0.95 (95%)

d) Influence of Airport Traffic on Land Transport

The air passenger traffic is analyzed separately in Appendix AP5. The airport traffic relation to the peak road traffic is briefly explained and summarized here.

Peak traffic on roads was found to be concentrated from 7 to 8 in the morning. The airport traffic which influences the peak road traffic is, therefore, the subject of concern. Concentration rates in corresponding periods were derived from the present flight operation schedule presented in Appendix Table AP5-14.

i) International air passengers:

	(Hour)	(Concentration Ratio)
Departing	from 8:00 to 9:00 a.m.	5.3%
Arriving	from 6:00 to 7:00 a.m.	1.6%

ii) Domestic air passengers:

Departing	from 8:00 to 9:00 a.m.	16.4%
Arriving	from 6:30 to 7:30 a.m.	0 %

Persons who meet or send off air passengers at the airport also contribute to peak road traffic. The volume of these persons are assumed to be as follows:

i) For international air passengers:

Foreign tourists	0.5 person per passenger
Other passengers	1.0 person per passenger

ii) For domestic air passengers: 0.5 person per passenger

Assuming that these conditions will not change in future, the person-trips which have an influence on the peak road traffic (from 7 to 8 a.m.) were estimated to be generated and attracted at the airport as shown in Table 5-7. The calculation is detailed in the Appendix Tables AP5-15 through AP5-18.

Table 5-7 PERSON-TRIPS GENERATED AND ATTRACTED AT AIRPORT DURING ROAD PEAK HOUR (7-8a.m.)

(Unit: Persons/hr.)

		1977	1990	2000
Present Bangkok Airport	Person-trips generated	95	230	None
	Person-trips attracted	384	929	287
* New Airport	Person-trips generated	-	-	354
	Person-trips attracted	-	-	1,174

Note: * Forecasts for the international airport, expected to be open to traffic by the year 2,000, were analyzed in the Appendix, AP5-4.

e) Establishment of O-D Matrices in 2000

Based on the gravity trip distribution model of the trips generated by the analysis of present O-D matrices, the O-D matrices for 2000 was established.

The established O-D matrices for the year 2000 are attached in the separate volume of computer output. Table 5-8 shows the estimated generated and attached person trips by zone in the peak hour.

f) Evaluation of the Established O-D Matrices

In this paragraph, the established O-D matrices are evaluated based on the comparison of both results of existing O-D matrices and future O-D matrices established in the study of "First Stage Mass Transit System in Bangkok". The estimated traffic volumes for GBA in various studies are summarized as follows.

Table 5-9 COMPARISON OF TRAFFIC VOLUME IN VARIOUS STUDIES

Source	Year	Number of Person-Trips for GBA (persons/day)	Remarks
BTS	1972	4,678,000	Internal Person Trips only Excluding Intrazonal Person Trips
First Stage Mass Transit System	1978	5,253,531	Excluding Intrazonal Person Trips
	1990	8,297,251	
	2000	10,834,000	Estimated by the linear equation
BSTP	1977	4,417,637	Excluding Intrazonal Person Trips
	2000	10,284,000	

Table 5-8 GENERATED AND ATTRACTED PERSON TRIPS, 2000

(Unit: 1,000 persons/Hr.)

Zone No.	Name of Zone	Generated	Attracted	Zone No.	Name of Zone	Generated	Attracted
1	Phra Nakhon	22.6	23.8	41	Bang Ko Bua	2.2	1.2
2	Dusit	27.0	28.6	42	Bang Yo	3.8	3.1
3	Bang Su	13.5	8.2	43	Bang Talat	14.3	18.3
4	Phayathai	58.7	62.5	44	Bang Chak	1.6	6.0
5	Pathumwan	26.4	37.0	45	Bang Ya Phraek	6.1	9.5
6	Yannawa	46.4	32.9	46	Samrong Tai	5.0	14.4
7	Bang Pong Pang	21.8	18.8	47	Samut Prakan	18.1	20.0
8	Bang Kapi	2.2	8.5	48	Bang Muang	6.0	5.1
9	Samsen	34.6	37.7	49	Samrong Nua	8.3	9.5
10	Lat Yao	41.2	49.6	50	Bang Duan	1.3	1.1
11	Thung Song Hong	4.4	3.4	51	Phraek Sa	8.6	6.4
12	Thung Si Kan	4.4	2.5	52	Thai Ban	3.0	9.9
13	Talat Bang Khen	6.5	6.1	53	Bang Pumai	2.9	12.0
14	Khlong Thanon	10.8	13.7	54	Bang Kaeo	5.1	3.2
15	Thareng	11.1	8.4	55	Bang Pli Yai	2.3	0.8
16	Lat Phrao	9.1	8.7	56	Bang Pla	2.3	0.8
17	Khlong Chan	16.1	15.8	57	Bang Chalong	0.9	0.7
18	Khlong Kum	26.7	28.2	58	Racha Thewa	7.5	12.0
19	Saphan Sung	3.0	1.8	59	Srisa Charakhe	1.6	0.9
20	Huamak	5.1	3.2	60	Bang Bo	10.1	5.7
21	Phra Khanong	23.7	41.1	61	Bang Pakok	4.5	8.2
22	Suan Luang	9.6	5.5	62	Laem Fa Pha	3.1	1.8
23	Bang Na	14.5	7.4	Sub-total	Samut Prakann	118.6	150.6
24	Nong Bon	13.0	12.6	63	Wat Chalo	2.9	2.0
25	Prawet	4.9	2.9	64	Bang Khanum	2.8	1.6
26	Bang Chan	3.7	2.1	65	Bang Kruai	0.8	0.8
27	Minburi	23.5	25.8	66	Nonthaburi	9.7	12.0
28	Lat Krabang	14.6	12.6	67	Bang Kraso	24.5	25.1
29	Nong Chok	8.5	13.1	68	Bang Krang	4.6	2.7
30	Bang O	18.0	19.0	69	Pak Kret	10.3	8.9
31	Sirrat	45.2	40.3	70	Om Kret	1.0	0.6
32	Thonburi	30.0	34.1	71	Bang Bua Thong	6.9	3.9
33	Rat Burana	12.7	11.2	Sub total	Nonthaburi	63.5	57.6
34	Thung Khru	5.4	4.2	Total	Greater Bangkok Area	874.1	888.7
35	Bang Khun Tian	28.4	21.7				
36	Phasi Charoen	15.4	9.1				
37	Taling Chan	5.6	3.1				
38	Sala Than Masop	2.8	1.6				
39	Nong Khaem	15.1	10.5				
40	Bang Bon	5.8	3.2				
Sub-total	Bangkok Metropolis	692	680.5				

Source: Estimated by the Team

According to the table, it is possible to say the results of this BSTP study parallel the results of previous studies. Therefore in this study, the established O-D matrices are used.

5.1.3 Forecast of Future Passenger Car Ownership

(1) Model Building for Regional Framework

In the transportation planning process, model building is an important part to explain the future as well as present relationships among independent and dependent variables. Within the limitation of data available, relatively good correlation was obtained between the dependent variable of motorization and the independent variables of per capita gross regional and provincial product (GRP and GPP) in the areas of the GBA outside Bangkok and the Central Region outside the GBA. The estimated linear regression equations for the above two regions are derived from the data presented in Tables 5-10 and 5-11.

Table 5-10 MOTORIZATION AND PER CAPITA GRP IN
GBA OUTSIDE BANGKOK

YEAR		1972	1973	1974	1975	1976
X:	Per Capita GRP ^{1/} (Baht at 1972 constant prices)	15,576	16,684	17,097	16,832	18,459
Y:	Motorization ^{2/} (cars/1000 population)	7.6	7.9	8.1	10.1	10.9
Estimated linear regression equation		$Y = 0.00113X - 10.23045$ (r = 0.800)				

Source: ^{1/} "Gross Provincial Product, 1977", NESDB

^{2/} Vehicle Registration Division, Police Department

Table 5-11 MOTORIZATION AND PER CAPIT GRP IN
CENTRAL REGION OUTSIDE GBA

YEAR		1972	1973	1974	1975	1976
X:	Per Capita GRP ^{1/} (Baht at 1972 constant prices)	4,917	5,273	5,225	5,397	5,840
	Motorization ^{2/} (cars/1000 population)	2.8	3.2	3.4	3.6	3.8
Estimated linear regression equation		$Y = 0.001X - 1.945$ (r: 0.921)				

Source: ^{1/} "Gross Provincial Product, 1977", NESDB

^{2/} Vehicle Registration Division, Police Department

However, for both Bangkok and the Central Region, no good correlation between the motorization and per capita GPP or GRP could be established.

(2) Economic Growth in Bangkok, GBA and Central Region

According to the Fourth Development Plan the average annual growth of Gross Domestic Product (GDP) in Thailand is expected to be 7.0% during 1977 - 81. Regional shares of GDP distributed to Central Region and Other Regions are 60% and 40% in 1977 respectively and are expected to rise to 62.7% in Central Region and fall eventually to 37.3% in the other Regions in 1981.

From the same data source it was found that per capita income in Bangkok and the rest of Central Region are expected to grow at an average of 4.3% and 5.1% per year during the plan period.

Taking account of these factors and the past development of economy the following economic parameters for the future were assumed as presented below.

i) Growth rate of Gross Domestic Product in Thailand:

7.0% per annum during 1978 - 1980
 6.0% per annum during 1981 - 1990
 5.0% per annum during 1991 - 2000

ii) Regional share of GDP to Central Region:

60% in 1977
 62% in 1980
 67% in 1990
 70% in 2000

iii) Growth rate of per capita income in both Bangkok and GBA:

4.3% per annum during 1978 - 1980
 3.5% per annum during 1981 - 1990
 3.0% per annum during 1991 - 2000

Based on the above assumptions, regional economic parameters in the year 2000 are calculated as shown in Table 5-12.

(3) Passenger Car Ownership in 2000

The previous linear regression equations in Tables 5-10 and 5-11 can be applied to forecast the future passenger cars in the GBA outside Bangkok and Central Region outside GBA. The independent variables of future per capita GRP has been shown in Table 5-12 so that the passenger cars in the year 2000 are estimated as follows.

Area	Passenger Cars	Motorization Rate (veh/1000 population)
GBA outside Bangkok	67,577	32.9
Central Region outside GBA	223,686	15.3

Table 5-12 THE PAST AND PROJECTED FUTURE ECONOMIC GROWTH BY REGION

YEAR	1975	1976	1977**	2000***
Metropolitan Bangkok				
Population(x1000)	4,360	4,550	4,740	8,056
GPP* (million ฿)	59,117	64,378	69,988	255,851
Per capita GPP(฿)	13,559	14,149	14,765	31,759
Share of GDP (%)	29.0	29.2	29.9	30.6
Greater Bangkok Area				
Population(x1000)	5,130	5,340	5,560	10,110
GRP* (million ฿)	72,162	79,053	85,440	334,226
Per capita GRP(฿)	14,067	14,804	15,367	33,059
Share of GDP (%)	35.4	35.9	36.5	39.9
GBA outside Metropolitan Bangkok				
Population(x1000)	770	790	820	2,054
GRP* (million ฿)	13,045	14,675	15,452	78,375
Per capita GPP(฿)	16,942	18,576	18,844	38,157
Share of GDP (%)	6.4	6.7	6.6	9.3
Central Region				
Population(x1000)	13,690	14,070	14,470	24,730
GRP* (million ฿)	118,331	130,038	140,526	585,659
Per capita GRP(฿)	8,644	9,242	9,712	23,682
Share of GDP (%)	58.1	59.0	60.0	70.0
Central Region outside GBA				
Population(x1000)	8,560	8,730	8,910	14,620
GRP* (million ฿)	46,169	50,985	55,086	251,433
Per capita GRP(฿)	5,394	5,840	6,182	17,198
Share of GDP (%)	22.7	23.1	23.5	30.1
Thailand				
Population(x1000)	41,870	42,960	44,040	73,500
GDP* (million ฿)	203,751	220,450	234,123	836,656
Per capita GDP(฿)	4,866	5,132	5,316	11,383
Share of GDP (%)	100.0	100.0	100.0	100.0

* At 1972 constant prices

** Estimated by NESDB

*** Estimated by the Team

Note: GPP - Gross Provincial Product
 GRP - Gross Regional Product
 GDP - Gross Domestic Product

The past motorization rate, in passenger cars per 1,000 population, in Bangkok has been fluctuating in spite of the continuous increase in per capita income. Therefore 3.4% of the average annual increase in motorization from 1975 to 1977 was taken as a growth factor resulting in a motorization rate of 109.4 in 2000. This motorization rate and per capita income in 2000 were compared with the selected foreign cities as shown in Table 5-13 and Fig. 5-3.

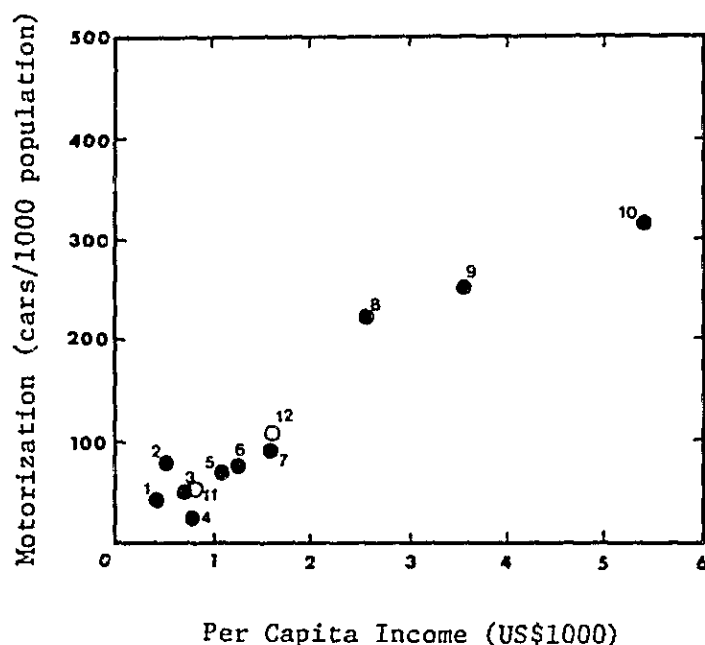
Table 5-13 MOTORIZATION AND PER CAPITA INCOME IN SELECTED CITIES 1970

No.	City	Motorization (Veh/1,000 persons)	Per Capita Income (US\$)
1	San Jose	47.9	430
2	Abidjan	75.5	500
3	Kuala Lumpur, Malaysia	51.9	660
4	Bogota, Colombia	22.0	760
5	Singapore	73.0	1,100
6	Mexico City	78.3	1,225
7	Caracas, Venezuela	91.0	1,600
8	London, U.K.	222.0	2,550
9	Paris, France	248.0	3,530
10	Washington, D.C.	316.0	5,390
11	Metro. Bangkok (1977)	50.7	750*
12	Metro. Bangkok (2000)	109.4	1,614*

* At 1970 constant price

Source: URBAN TRANSPORT, Sector Policy Paper - World Bank, 1975

Fig. 5-3 RELATIONSHIP BETWEEN MOTORIZATION AND PER CAPITA INCOME IN SELECTED CITIES



Thus, the estimated motorization rate in Bangkok for the year 2000 falls within the general range of other cities judging from the above diagram.

In summary, the motorization rate and passenger car ownership in the year 2000 are thus estimated as given in Table 5-14.

Table 5-14 ESTIMATED MOTORIZATION RATE AND PASSENGER CARS BY REGION IN THE YEAR 2000

	Population (x1000)	Passenger Cars	Motorization (cars/1000 pop.)
Metropolitan Bangkok	8,056	881,326	109.4
Greater Bangkok Area (GBA)	10,110	948,903	93.9
GBA Outside Bangkok	2,054	67,577	32.9
Central Region	24,730	1,172,589	47.4
Central Region outside GBA	14,620	223,686	15.3

(4) Zonal Distribution of Regional Framework in 2000

a) Estimation Process

Methodological flow charts are introduced below to estimate the future passenger car ownership by zone.

i) Greater Bangkok Area

The Greater Bangkok Plan indicates the maximum gross population density by land use type. According to this, the gross population densities in the high density mixed-use, low density mixed-use and agricultural areas are 375 inh./ha, 75 inh./ha and 6 inh./ha respectively. At the same time, the areas of these different land uses in the GBA and in each zone were measured on the 2000 Land Use Map.

Based on these areas and population densities, zonal population as well as GBA population will be calculated in the classification of different land uses. However, the populations of GBA and each zone in 2000 have already been estimated earlier in Chapter 2. The populations by different land use are adjusted to these control totals.

On the other hand, socio-economic survey conducted in 1976 for GBA presents by land use pattern different amounts of household's expenditures to automobile operation, maintenance and purchases. These are given in Table 5-15.

These differences in the expenditures among the above land use patterns are regarded as the weighting factors to differentiate motorization rates among the future land use patterns of high density mixed-use, low density mixed-use and agricultural areas.

Fig. 5-4 METHODOLOGICAL FLOW CHART FOR ESTIMATION OF ZONAL CAR OWNERSHIP IN GBA IN THE YEAR 2000

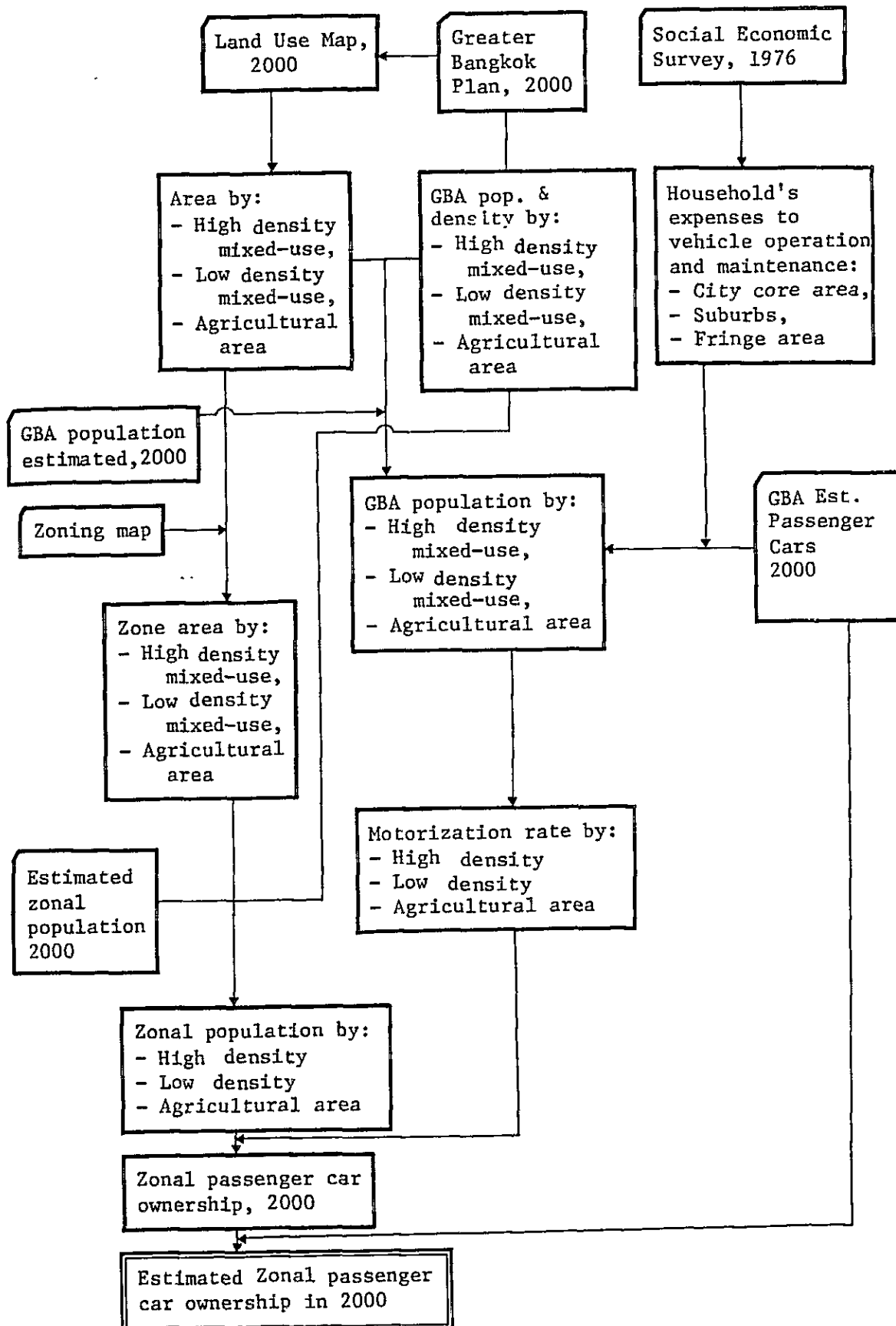


Table 5-15 AUTOMOBILE OPERATION AND PURCHASE COSTS
PER HOUSEHOLD BY LAND USE PATTERN, 1976

(Unit: Baht/month)

Item	City Core	Suburbs	Fringe Area	GBA
• Gasoline	83.46	51.14	28.17	62.45
• Oil and lubrication	9.14	4.57	4.41	6.84
• Maintenance & Repair	32.48	30.76	10.68	27.31
• Tyres and batteries	1.04	0.61	0.34	0.76
• Licences & registration	2.54	1.55	0.10	1.77
• Other expenses	2.47	0.63	6.38	2.78
Vehicle operation	131.13	89.26	50.08	101.91
Automobile purchases	56.14	39.56	13.33	42.25
Total	187.27	128.82	63.41	144.16
Average household size	5.6	5.6	5.7	5.7
Per capita vehicle operation & purchase costs	3.44	23.00	11.12	25.29

Source: "Socio-Economic Survey, 1975-1976 Greater Bangkok Metropolitan Area", National Statistical Office

Since the passenger car ownership in GBA has been estimated for the year 2000 in section 5-1-3 (3) future motorization rates by different land use can be derived accordingly.

With these motorization rates and zonal population classified by high density mixed-use, low density mixed-use and agricultural areas, zonal ownership of passenger cars in 2000 will be calculated and then adjusted according to the control total of the GBA passenger cars in 2000.

The zonal ownership of passenger cars in 2000 thus obtained are presented in Table 5-16.

ii) Central region outside GBA

The past development of the motorization by zone indicates mostly the steady increase as shown in Table 5-17. However, in some zones it is fluctuating. Hence, the zones in Central Region outside GBA are divided into two groups. One is the zones adjacent to the GBA, namely zones 72 to 83. The other is the rest of zones in Central Region, namely zones 84 to 88.

Time series linear regression equations of the motorization level were estimated for the above two groups of zones and the motorization in each group for the year 2000 was projected. The estimated average growth rates in motorization of the two groups from 1977 to 2000 were then applied to the zones of the disordered development of motorization in the past.

Table 5-16 ESTIMATED PASSENGER CARS BY ZONE IN GBA, 2000

Zone No.	Name of Zone	Passenger Cars	Motorization (cars/1000 pop.)	Zone No.	Name of Zone	Passenger Cars	Motorization (cars/1000 pop.)
1	Phra Nakhon	33,815	123.9	41	Bang Ko Bua	649	29.9
2	Dusit	40,305	123.9	42	Bang Yo	1,427	34.0
3	Bang Su	11,652	85.1	43	Bang Talat	7,495	43.2
4	Phayathai	87,388	123.9	44	Bang Chak	568	29.9
5	Pathumwan	48,964	123.9	45	Bang Ya Phraek	2,845	38.3
6	Yannawa	55,078	111.9	46	Samrong Tai	1,829	29.9
7	Bang Pong Pang	27,406	110.7	47	Samut Prakan	9,387	43.0
8	Bang Kapi	3,430	119.5	48	Bang Muang	2,265	33.0
9	Samsen	49,803	119.6	49	Samrong Nua	3,380	34.4
10	Lat Yao	58,696	118.1	50	Bang Duan	451	29.9
11	Thung Song Hong	4,043	85.1	51	Phraek Sa	2,784	29.9
12	Thung Si Kan	3,595	83.8	52	Thai Ban	1,106	29.9
13	Talat Bang Khen	7,991	101.7	53	Bang Pumai	969	27.5
14	Khlong Thanon	13,532	103.1	54	Bang Kaeo	1,608	30.1
15	Thareng	9,830	82.5	55	Bang Phli Yai	191	14.5
16	Lat Phrao	11,472	106.5	56	Bang Pla	183	14.5
17	Khlong Chan	19,182	100.2	57	Bang Chalong	127	14.4
18	Khlong Kum	33,540	104.5	58	Racha Thewa	2,857	31.9
19	Saphan Sung	2,579	85.1	59	Srisa Charakhe	295	20.1
20	Huamak	4,537	85.1	60	Bang Bo	1,445	14.5
21	Phra Khanong	33,559	117.7	61	Bang Pakok	1,591	29.8
22	Suan Luang	8,129	85.1	62	Laem Fa Pha	569	18.2
23	Bang Na	17,579	100.2	Sub-total	Samut Prakan	44,019	33.0
24	Nong Bon	14,959	97.5	63	Wat Chalo	930	29.7
25	Prawet	4,196	85.1	64	Bang Khanum	723	27.0
26	Bang Chan	2,146	58.8	65	Bang Kruai	107	14.5
27	Minburi	30,217	106.5	66	Nonthaburi	4,228	36.2
28	Lat Krabang	16,491	98.6	67	Bang Kraso	11,470	38.6
30	Bang O	24,616	114.2	68	Bang Krang	1,303	29.1
31	Sirirat	62,050	119.2	69	Pak Kret	3,643	31.1
32	Thonburi	44,752	123.9	70	Om Kret	145	14.5
33	Rat Burana	15,031	103.0	71	Bang Bua Thong	1,009	14.5
34	Thung Khru	5,445	91.1	Sub-total	Nonthaburi	23,558	32.7
35	Bang Khun Tian	31,995	103.3	Total	Greater Bangkok Area	948,903	93.9
36	Phasi Charoen	13,350	86.2				
37	Taling Chan	4,170	74.6				
38	Sala Than Masop	1,138	41.2				
39	Nong Khaem	13,333	83.7				
40	Bang Bon	3,983	68.4				
Sub-total	Bangkok Metropolis	881,326	109.4				

The zones with relatively smooth increase in motorization have provided good correlation between zonal motorization and time sequence. Therefore, the regression equations for these zones were calculated and the future motorization by zone was derived for the year 2000.

So far, the zonal motorizations in 2000 were derived from the estimated regression equations. Consequently, zonal ownership of passenger cars can be calculated based on the zonal population estimated previously in Chapter 2. However, the results do not coincide with the total passenger cars of Central Region outside the GBA, which was determined in the early part of this section for the future regional framework of the passenger car ownership in 2000. Therefore, zonal passenger cars estimated above are taken as the distribution weights of the control total to obtain the final estimates of passenger car ownership by zone as summarized in Table 5-18.

Table 5-17 MOTORIZATION BY ZONE IN CENTRAL REGION OUTSIDE GBA

(Unit: Cars/1000 pop.)

Zone Number	Name of Zone	1972	1973	1974	1975	1976
72	Pathum Thani	1.6	1.9	2.4	2.9	3.6
73	Sam Khok	1.6	1.9	2.4	2.9	3.6
74	Khlong Luang	1.6	1.9	2.4	2.9	3.6
75	Suphanburi	1.2	1.3	1.3	1.3	1.6
76	Ayuthaya	1.0	2.7	1.7	1.7	2.0
78	Nakhon Nayok	1.8	2.0	1.9	1.5	2.1
79	Chachoengsao	1.4	1.4	1.5	1.6	1.8
80	Chonburi	6.3	6.6	8.1	8.4	8.7
81	Samut Sakhon	1.2	1.5	1.8	3.0	4.8
82	Nakhon Pathom	4.1	4.6	5.2	5.3	6.6
83	Ratchaburi	3.4	3.5	3.2	3.5	3.2
84	Samut Songkhram	1.5	2.2	2.1	2.3	2.3
85	Kanchanaburi	3.0	2.9	2.5	2.7	3.1
86	Lopburi	1.8	2.1	2.4	2.7	2.7
87	Prachinburi	1.2	1.3	1.4	1.3	1.2
88	Rayong	5.8	6.2	6.7	7.1	7.1
Central Reg. outside GBA		2.8	3.2	3.4	3.6	3.8

Table 5-18 ESTIMATED PASSENGER CARS BY ZONE IN CENTRAL REGION
OUTSIDE GBA, 2000

Zone Number	Name of Zone	Population P (x 1,000)	Passenger Cars	Motorization Rate (cars/1,000 pop.)
72	Pathum Thani	63.6	1,408	22.1
73	Sam Khok	88.9	1,968	22.1
74	Khlong Luang	389.5	8,623	22.1
75	Suphanburi	1,110.9	5,395	4.9
76	Ayuthaya	859.6	9,577	11.1
77	Saraburi	680.1	21,274	31.3
78	Nakhon Nayok	273.5	2,382	8.7
79	Chachoengsao	298.5	1,748	5.9
80	Chonburi	563.4	19,716	35.0
81	Samut Sakhon	280.8	10,067	35.9
82	Nakhon Pathom	858.4	24,522	28.6
83	Ratchaburi	852.8	11,207	13.1
84	Samut Songkhram	1,731.1	16,072	9.3
85	Kanchanaburi	1,040.2	8,617	8.3
86	Lopburi	1,877.9	23,068	12.3
87	Prachinburi	1,235.8	3,884	3.1
88	Rayong	2,415.0	54,158	22.4
	Central Reg. Outside GBA	14,620.0	223,686	15.3

5.1.4 Average Daily Commercial Vehicle Trips

(1) Analysis of Existing Average Trip Ratio

According to the Bangkok Transportation Study Report, the average daily trip ratio was 4.0 in 1972 but there is no other data on commercial vehicle trips. Therefore, to see the change in trip ratio from 1972 to 1977, commercial vehicle ownership and the growth of cross sectional commercial vehicle traffic in the same period were considered. If the average travel length per commercial vehicle remains constant, it can be presumed that the increase in total trips by commercial vehicles is derived by multiplying the increase in the ownership by the increase in the trip ratio. If the increase in total trips falls in proximity with the growth of observed cross sectional traffic volume, the increase in the trip ratio can be estimated from the following equation and data.

$$\frac{TV_{77}}{TV_{72}} = \frac{CV_{77}}{CV_{72}} \times \frac{TR_{77}}{TR_{72}} \times \frac{D_{77}}{D_{72}}$$

where,

TV : Total commercial vehicle traffic volume by cross section in 1972, 1977 (TV₇₂, TV₇₇)

CV : Total commercial vehicle ownership in 1972, 1977 (CV₇₂, CV₇₇)

TR : Average trip ratio in 1972, 1977 (TR₇₂, TR₇₇)

D : Average daily travel distance per C.V. in 1972, 1977 (D₇₂, D₇₇)

Summary of Data & Calculation

Year	<u>1/</u> Daily average traffic volume cross section	<u>2/</u> Commercial vehicles ownership	Trips/c.v.	km/c.v.
Symbol	TV	CV	TR	D
1972	49,439 veh.	45,255 veh.	4.0	36.0
1977	73,680 veh.	73,254 veh.	* 3.7	** 36.0

* Calculated by the equation above ** Assumed

Note 1/ : Derived from the 19 traffic count stations set up on the outskirts of GBA by the Department of Highways

2/ : Commercial vehicles registered in the GBA, the 1977 figure has been estimated in Chapter 2.

Assuming that the average travel distance per vehicle is unchanged, the average trip ratio in 1977 is calculated to be 3.7 trips per vehicle accordingly.

For the discussion of average travel distance per vehicle, it is necessary to take note of the change in composition of commercial vehicle sizes. However, such detailed information about the size is not available and is only suggested by the classification of private and hired trucks. That is, the private trucks consist largely of vans and light trucks and hired trucks consist mostly of heavy trucks. According to the data from the Vehicle Registration Division of Police Department the hired trucks has decreased both in Bangkok and the GBA.

Number of Trucks Registered

(Unit: Vehicles)

	Metropolitan Bangkok		Greater Bangkok Area	
	Private	Hired	Private	Hired
1972	44,740	8,554	46,468	8,821
1976	75,679	6,727	79,819	6,953
1976/1972	1.692	0.786	1.718	0.788

Source: Vehicle Registration Division, Police Department

In contrast with this, the private trucks has increased remarkably both in Bangkok and the GBA as shown in the above table. Therefore, it was assumed that the growth of ownership of light trucks is higher than that of heavy trucks and so that the average travel length per commercial vehicle may be shorter in 1977 than in 1972.

Based on the above considerations, trip ratio in 1977 was determined to be the same as in 1972 ratio of 4.0.

(2) Forecast of Future Average Trip Ratio

It is very difficult to estimate the future trip ratio. Several factors attributable to the trip ratio can be the level of commercial vehicle ownership, population, number of jobs, total jobs per population or per unit area, trip distance, mode availability, land use characteristics, etc. Among these, no single factor alone determines the future trip ratio.

As a reference, the cases from Japan and foreign cities are introduced in Tables 5-19 and 5-20.

Taking account of the levels of commercial vehicle ownership and the populations in the above cities, 5.6 was taken as an average future commercial vehicle trip ratio in the GBA and other Changwats of the Central Region.

(3) Forecast of Future Commercial Vehicle Ownership

a) Model Building for Regional Framework

For the estimation of future commercial vehicle ownership several forecasting models have been examined with such independent variables as motorization of passenger cars, Gross Regional Product (GRP), GRP per Capita, Jobs and GRP per Job. As a result the following regression equations were estimated with relatively good correlation for the future commercial vehicle ownership by region.

Table 5-19 COMMERCIAL VEHICLE TRIP RATIO AND OWNERSHIP RATIO
BY SIZES OF URBAN AREAS AND CITIES IN JAPAN

Population (x 1,000)	1962		1965	
	Trip Ratio ^{1/}	Ownership ^{2/} Ratio	Trip Ratio ^{1/}	Ownership ^{2/} Ratio
- Urban area -				
3,000 ~	-	33.5	4.14	54.1
1,000 ~ 3,000	-	22.0	4.53	47.4
500 ~ 1,000	-	20.4	5.48	30.9
300 ~ 500	-	25.4	3.97	46.8
200 ~ 300	-	22.3	5.41	40.4
100 ~ 200	-	-	4.01	41.5
50 ~ 100	-	-	3.45	55.9
~ 50	-	-	3.05	55.7
- City -				
1,000 ~	-	-	4.23	28.8
500 ~ 1,000	4.9	30.0	4.45	47.9
300 ~ 500	5.6	29.8	5.05	51.1
200 ~ 300	5.1	24.4	5.87	47.9

Note ^{1/} : Average trips per vehicle

^{2/} : Commercial vehicles per 1,000 population

Source : "TOSHI KOOTSU KOZA 1, TOSHI TO KOOTSU" by
Dr. Yoshinosuke Yasoshima, 1975

Table 5-20 COMMERCIAL VEHICLE TRIP RATIO AND OWNERSHIP RATIO
IN SEVERAL FOREIGN CITIES

City	Year	Commercial Vehicles	C.V. Trips per day	Trips/C.V.	C.V. per 1,000 pop.
Singapore	1968	29,300	117,821	4.02	14.7
Athens, Greece	1962	23,000	127,000	5.52	12.1
Tel Aviv, Israel	1965]	13,070	118,750	9.09	16.0
Hull, U.K.	1967	9,469	69,100	7.30	27.5
London	1962	190,754	1,062,419	5.57	21.6
West Midlands	1964	53,956	341,749	6.33	21.3
Pittsburgh, U.S.	1958	41,903	229,409	5.47	28.5
Baltimore, U.S.	1962	47,938	378,029	7.89	29.8
Chicago, U.S.	1956	130,000	827,590	6.37	25.1
Baton Rouge	1965	9,101	81,431	8.95	37.1
GBA (est.)	1977	73,254	293,016	4.0	13.2
	2000	225,104	1,260,582	5.6	22.3

Source: World Bank Staff Working Paper No. 230 - TRAVEL CHARACTERISTICS IN CITIES OF DEVELOPING AND DEVELOPED COUNTRIES, 1976 -

i) Greater Bangkok Area:	$\log Y = 0.9153 \log X + 0.2940$ (r: 0.882) where, X: GRP (million Baht) Y: Commercial vehicles
ii) GBA outside Bangkok:	$\log Y = 1.313 \log X - 1.879$ (r: 0.893) where, X: GRP (million Baht) Y: Commercial vehicles
iii) Central Region :	$Y = 4.4939X - 24,525.1$ (r: 0.934) where, X: GRP (million Baht) Y: Passenger cars plus commercial vehicles

Future passenger cars and Gross Regional Product in 2000 have been estimated previously in 5.1.3(2) and (3).

Commercial vehicles in 2000, therefore, are calculated as shown in Table 5-21.

(4) Zonal Distribution of Regional Framework in 2000

a) Metropolitan Bangkok

The commercial vehicle ownership in 2000 estimated for Metropolitan Bangkok is distributed to the zones proportionally to the future jobs of both secondary and tertiary sectors in each zone as shown in Table 5-22.

b) Samut Prakan and Nonthaburi

Time-series linear regression equations of commercial vehicles are estimated for each of the two Changwats. Commercial vehicles in the year 2000 for Samut Prakan and Nonthaburi are calculated from the estimated equations and these are used as the weighting factors to distribute to each Changwat the total commercial vehicle ownership determined previously for the GBA outside Metropolitan Bangkok.

To estimate the zonal commercial vehicles the same method as applied to Metropolitan Bangkok is employed and the final estimates for each zone are derived as presented in Table 5-22.

c) Central Region outside GBA

To reflect the past development of commercial vehicle ownership by Changwat, time-series simple regression equations are estimated for each Changwat of Central Region outside GBA. The ownership levels calculated from the above equations for the year 2000 are taken as the distribution factors to arrive

Table 5-21 ESTIMATED COMMERCIAL VEHICLES AND PASSENGER CARS BY REGION IN 2000

YEAR	1976	1977	2000	YEAR	1976	1977	2000
Metropolitan Bangkok				Central Region outside GBA			
Pop. (x 1,000)	4,546	4,743	8,056	Population (x 1,000)	8,731	8,901	14,620
Passenger cars	215,599	240,638	881,326	Passenger cars	33,453	36,680	223,686
Motorization (cars/1,000 pop.)	47.4	50.7	109.4	Motorization (cars/1,000 pop.)	3.8	4.1	15.3
Commercial vehicles	61,474	68,579	189,798	Commercial vehicles	105,085	121,101	623,991
Comm. veh./1,000 population	13.5	14.5	23.6	Comm. veh./1,000 population	12.0	13.6	42.7
GBA outside Metropolitan Bangkok				Total Central Region			
Population (x 1,000)	795	822	2,054	Population	14,072	14,466	24,730
Passenger cars	8,702	9,826	67,577	Passenger cars	257,754	287,144	1,172,589
Motorization (cars/1,000 pop.)	10.9	12.0	32.9	Motorization (cars/1,000 pop.)	18.3	19.8	47.4
Commercial vehicles	4,366	4,675	35,306	Commercial vehicles	170,925	194,355	849,095
Comm. veh./1,000 population	5.5	5.7	17.2	Comm. veh./1,000 population	12.1	13.4	34.3
Sub-Total Greater Bangkok Area (GBA)							
Population (x 1,000)	5,341	5,565	10,110				
Passenger cars	224,301	250,464	948,903				
Motorization (cars/1,000 pop.)	42.0	45.0	93.9				
Commercial vehicles	65,840	73,254	225,104				
Comm. veh./1,000 population	12.3	13.2	22.3				

Table 5-22 ESTIMATED COMMERCIAL VEHICLES BY ZONE IN GBA, 2000

Zone No.	Name of Zone	Commercial Vehicles	Zone No.	Name of Zone	Commercial Vehicles
1	Phra Nakhon	6,816	41	Bang Ko Bua	120
2	Dusit	8,193	42	Bang Yo	424
3	Bang Su	1,685	43	Bang Talat	2,662
4	Phayathai	17,869	44	Bang Chak	886
5	Pathumwan	10,578	45	Bang Ya Phraek	1,387
6	Yannawa	7,754	46	Samrong Tai	2,106
7	Bang Pong Pang	5,008	47	Samut Prakan	2,899
8	Bang Kapi	2,462	48	Bang Muang	688
9	Samsen	10,770	49	Samrong Nua	1,364
10	Lat Yao	14,209	50	Bang Duan	159
11	Thung Song Hong	854	51	Phraek Sa	733
12	Thung Si Kan	477	52	Thai Ban	1,445
13	Talat Bang Khen	2,131	53	Bang Pumai	1,756
14	Khlong Thanon	3,962	54	Bang Kaeo	357
15	Thareng	2,023	55	Bang Phli Yai	74
16	Lat Phrao	2,469	56	Bang Pla	70
17	Khlong Chan	4,431	57	Bang Chalong	62
18	Khlong Kum	8,062	58	Racha Thewa	1,737
19	Saphan Sung	338	59	Srisa Charakhe	82
20	Huamak	715	60	Bang Bo	560
21	Phra Khanong	11,878	61	Bang Pakok	1,185
22	Suan Luang	1,054	62	Laem Fa Pha	175
23	Bang Na	5,508	Sub-total	Samut Prakan	20,971
24	Nong Bon	3,585	63	Wat Chalo	448
25	Prawet	546	64	Bang Khanum	282
26	Bang Chan	408	65	Bang Kruai	79
27	Minburi	7,416	66	Nonthaburi	3,215
28	Lat Krabang	3,385	67	Bang Kraso	6,755
29	Nong Chok	3,739	68	Bang Krang	470
30	Bang O	5,416	69	Pak Kret	2,262
31	Sirirat	10,939	70	Om Kret	101
32	Thonburi	9,755	71	Bang Bua Thong	723
33	Rat Burana	3,008	Sub-total	Nonthaburi	14,335
34	Thung Khru	1,092	Total	GBA	225,104
35	Bang Khun Tian	5,393			
36	Phasi Charoen	1,816			
37	Taling Chan	623			
38	Sala Than Masop	308			
39	Nong Khaem	2,477			
40	Bang Bon	646			
Sub-total	Bangkok Metropolis	189,798			

at the determined commercial vehicles owned in Central Region outside GBA, which has been already estimated in 5.1.4(3).

The estimated regression equations and the adjusted future ownership levels of commercial vehicles by Changwat are presented in the Appendix, Table AP 5-19.

Subsequently, the future ownership levels by Changwat are to be transformed to the zones in proportion to the Tambon population, which means the jobs per population are constant in every Tambon, and the future Changwat's commercial vehicles are distributed to the Tambons and then consolidated to form zones.

In such a way, future commercial vehicle ownership by zone are derived and summarized in Table 5-23.

Table 5-23 ESTIMATED COMMERCIAL VEHICLES BY ZONE IN CENTRAL REGION OUTSIDE GBA, 2000

Zone No.	Name of Zone	Commercial Vehicles
72	Pathum Thani	976
73	Sam Khok	1,078
74	Khlong Luang	2,922
75	Suphanburi	32,587
76	Ayuthaya	11,002
77	Saraburi	25,687
78	Nakhon Nayok	3,235
79	Chachoengsao	5,004
80	Chonburi	58,988
81	Samut Sakhon	5,827
82	Nakhon Pathom	79,438
83	Ratchaburi	20,737
84	Samut Songkhram	52,702
85	Kanchanaburi	54,006
86	Lopburi	47,683
87	Prachinburi	9,274
88	Rayong	212,845
Sub-Total	Central Reg. outside GBA	623,991
Total	Central Region	849,095

(5) Inter-Zonal Commercial Vehicle Trips by Zone in 1977

The existing commercial vehicle ownership by zone is estimated previously in Table 2-10A and 2-10B. The average daily trips per commercial vehicle is also estimated in 5.1.4(1) to be 4.0 trips per vehicle. Therefore, the inter-zonal trip ends for each zone are estimated on the assumptions that the intra-zonal trip rates will be 60%, 80% and 90% for the GBA zones, zones 72 to

83 and zones 84 to 88 respectively. These intra-zonal trip rates were determined by taking consideration of the areas and populations of the zones and comparison was made with the similar cities in Japan. Some intra-zonal trip rates were examined by trial and error to reach the satisfactory result of traffic volume compared with screen line traffic volume obtained from the survey. Besides of this, the effective working rate of a commercial vehicle is considered to be 5.5 days per week.

Consequently, the inter-zonal trip ends were obtained as given in Table 5-24.

(6) Forecast of Future Inter-Zonal Commercial Vehicle Trips by Zone, 2000

The future commercial vehicle ownership by zone and the average future trip rate have been already estimated. By making the same assumptions established above for the intra-zonal trip rates and effective working rate of a vehicle, the inter-zonal trip ends in 2000 are estimated for each zone as shown in Table 5-24.

For the analysis of peak hour traffic from 7 a.m. to 8 a.m., an average concentration rate for commercial vehicle traffic over the average daily commercial vehicle traffic is estimated from the traffic count survey undertaken for the Outer Bangkok Ring Road Study. Thus, the average concentration rate is found to be 3.2% of the average daily commercial vehicle traffic.

Taking this into consideration, the commercial vehicle trips generated and attracted by zone are estimated for both average daily and peak hour (7:00 - 8:00 a.m.) basis as shown in Table 5-24.

Table 5-24 INTER-ZONAL COMMERCIAL VEHICLE TRIP ENDS
BY ZONE IN 1977 AND 2000

Zone Number	Name of Zone	Inter-zonal Trip Ends/day in 1977	Inter-zonal Trip Ends/day in 2000	Inter-zonal Trip Ends/peak hour in 2000	Zone Number	Name of Zone	Inter-zonal Trip Ends/day in 1977	Inter-zonal Trip Ends/day in 2000	Inter-zonal Trip Ends/peak hour in 2000
1	Phra Nakhon	15,468	24,001	768	48	Bang Muang	118	2,423	78
2	Dusit	12,878	28,850	923	49	Samrong Nua	387	4,803	154
3	Bang Su	3,878	5,933	190	50	Bang Duan	48	560	18
4	Phayathai	20,283	62,922	2,014	51	Phraek Sa	25	2,722	87
5	Pathumwan	16,246	37,248	1,192	52	Thai Ban	387	5,088	163
6	Yannawa	9,424	27,304	874	53	Bang Puma	423	6,183	198
7	Bang Pong Pang	4,522	17,635	564	54	Bang Kaeo	30	1,257	40
8	Bang Kapi	1,258	8,669	277	55	Bang Phli Yai	70	261	8
9	Samsen	3,292	37,924	1,214	56	Bang Pla	30	246	8
10	Lat Yao	7,593	50,034	1,601	57	Bang Chalong	93	218	7
11	Thung Song Hong	556	3,007	96	58	Racha Thewa	40	6,116	196
12	Thung Si Kan	468	1,680	54	59	Srisa Charakhe	60	289	9
13	Talat Bang Khen	1,886	7,504	240	60	Bang Bo	302	1,972	63
14	Khlong Thanon	2,005	13,951	446	61	Bang Pakok	377	4,173	134
15	Thareng	1,376	7,124	228	62	Laem Fa Pha	206	616	20
16	Lat Phrao	483	8,694	278	S-total	Samut Prakan	6,615	73,845	2,365
17	Khlong Chan	1,990	15,603	499	63	Wat Chalo	332	1,578	50
18	Khlong Kum	1,273	28,389	908	64	Bang Khanum	128	993	32
19	Saphan Sung	88	1,190	38	65	Bang Kruai	55	278	9
20	Huamak	1,112	2,518	81	66	Nonthaburi	1,398	11,321	362
21	Phra Khanong	14,296	41,826	1,338	67	Bang Kraso	830	23,786	761
22	Suan Luang	1,258	3,711	119	68	Bang Krang	314	1,655	53
23	Bang Na	5,033	19,395	621	69	Pak Kret	1,077	7,965	255
24	Nong Bon	425	12,624	404	70	Om Kret	259	356	11
25	Prawet	1,170	1,923	62	71	Bang Bua Thong	747	2,546	81
26	Bang Chan	264	1,437	46	S-total	Nonthaburi	5,140	50,478	1,614
27	Munburi	775	26,224	836	Total	Greater Bangkok Area	184,246	792,657	25,366
28	Lat Krabang	659	11,920	381	72	Pathum Thani	200	1,718	55
29	Nong Chok	702	13,166	421	73	Sam Khok	221	1,898	61
30	Bang O	4,125	19,071	610	74	Khlong Luang	599	5,145	165
31	Sirirat	11,575	38,519	1,233	75	Suphanburi	7,468	57,374	1,836
32	Thonburi	12,817	34,350	1,099	76	Ayuthaya	3,075	19,371	620
33	Rat Burana	3,541	10,592	339	77	Saraburi	8,148	45,226	1,447
34	Thung Khru	395	3,845	123	78	Nakhon Nayok	1,073	5,696	182
35	Bang Khun Tian	3,657	18,990	608	79	Chachoengsao	1,124	8,810	282
36	Phasi Charoen	2,093	6,395	205	80	Chonburi	13,951	103,857	3,323
37	Taling Chan	687	2,194	70	81	Samut Sakhon	1,615	10,259	328
38	Sala Than Masop	146	1,085	35	82	Nakhon Pathom	17,913	139,862	4,476
39	Nong Khaem	1,725	8,722	279	83	Ratchaburi	5,824	36,510	1,168
40	Bang Bon	1,009	2,275	73	84	Samut Songkhram	6,368	46,395	1,485
S-total	Bangkok Metropolis	172,491	668,334	21,387	85	Kanchanaburi	6,357	47,543	1,521
41	Bang Ko Bua	123	423	14	86	Lopburi	5,816	41,976	1,343
42	Bang Yo	171	1,493	48	87	Prachinburi	1,155	8,164	261
43	Bang Talat	943	9,374	300	88	Rayong	25,847	187,372	5,996
44	Bang Chak	443	3,120	100	Total	Central Reg. outside GBA	106,754	767,176	24,549
45	Bang Ya Phraek	372	4,884	156	G-total	Central Region	291,000	1,559,833	49,915
46	Samrong Tai	1,220	7,416	237					
47	Samut Prakan	747	10,208	327					