CHAPTER 3: IDENTIFICATION OF URBAN ENVIRONMENTAL PROBLEMS AND PLANNING IMPLICATIONS

3.1 A General View

To explore the existing conditions of the urban environment in Bangkok, the study team categorized urban environment into four components such as receptacle, urban anabolism, urban function and urban catabolism.

(1) Receptacle

Bangkok can be considered as a receptacle of peoples' activities. Natural conditions and the limited space of the city heavily affect urban activities and characterize the environmental problems. In this sense, Bangkok has unique characteristics in terms of climate and geography. It affects on flood, air pollution and water pollution.

(2) Urban Anabolism (Inputs for Urban Activities)

Urban anabolism means inputs to urban activities such as water, energy and material supplies, since a city can not alive by self-sustenance. Modern technology and financial capabilities can overcome problems related to urban anabolism. However, measures taken with a short-term view sometimes cause larger-term problems.

Problems concerning energy and food supplies are excluded from the study.

(3) Urban Function

Urban function covers activities carried out in Bangkok. Using the inputs, Bangkok carries out activities such as economic activities, urban development, transport and peoples' living.

Since the rapid economic growth from the mid-1980 in Thailand, various economic functions have been concentrated in Bangkok. Expansion of the middle-income group enlarge the domestic market, especially with regard to vehicles, construction and real estate markets. The number of private cars rapidly increased and urban development activities by the private sector such as construction of office and commercial buildings, housing projects and the development of manufacturing facilities accelerated. This resulted in extreme overcrowding in the urban centers and the unexpected expansion of the urbanized areas in the suburban areas, resulting in severe deterioration of the urban and suburban areas and of the natural environment.

(4) Urban Catabolism (Outputs from Urban Activities)

Presently, Bangkok suffers from several urban environmental problems such as air pollution, water pollution of rivers and khlongs, difficulty of garbage disposal and traffic noise. These problems appear to be caused by the urban functions.

The meaning of urban catabolism is the management of outputs from the urban functions. The urban environmental problems appear significantly here.

To improve the urban environment, it is necessary to take account not only of the problem of urban catabolism but also of the problems of the receptacle, urban anabolism and the urban function. The urban environmental planning aims at reforming the receptacle in order to balance with nature, through restructuring urban anabolism, the urban function and urban catabolism on the one hand, and mitigating/solving current problems on the other hand. Both measures should be coordinated in the urban environmental plan. In the following sections current urban environmental problems are discussed.

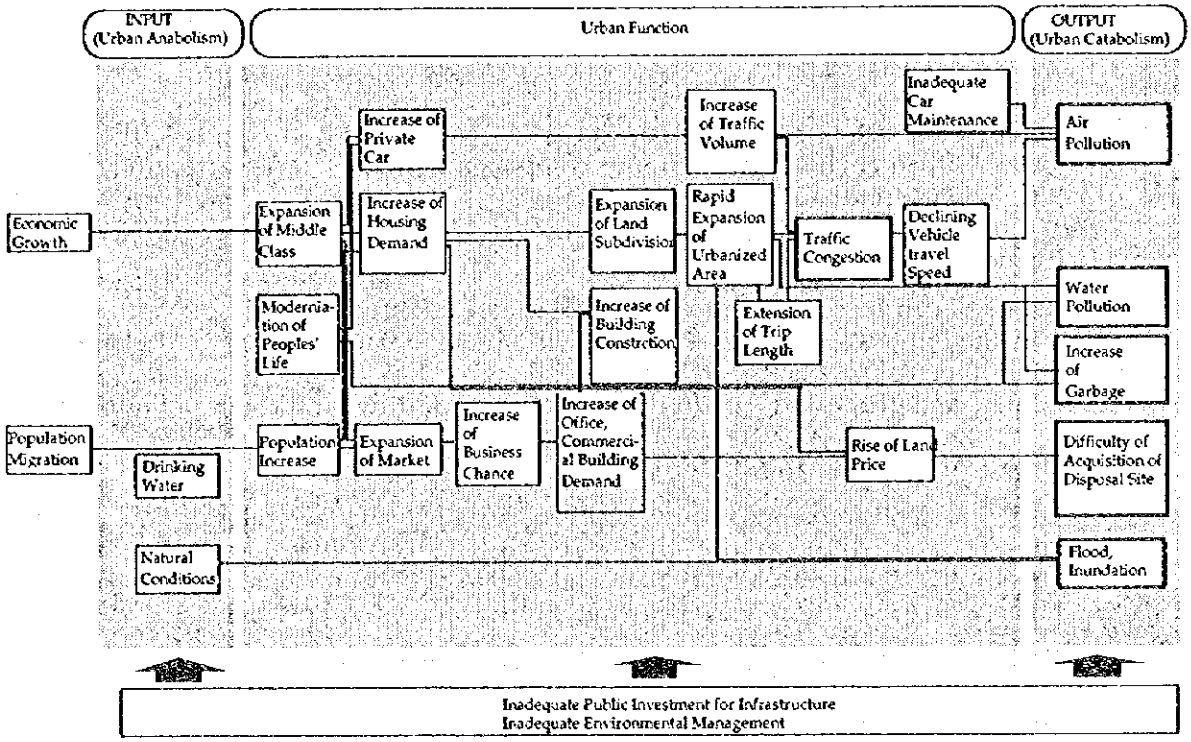


Fig. 3.1 Co-relation of Urban Environmental Problems (A Rough Concept)

3.2 Natural Conditions

(1) Tropical Climate

Bangkok experiences too much precipitation in the monsoon season (more than 300 mm per month) and too little in dry season (less than 10 mm per month). This naturally causes floods in the monsoon season and droughts in the dry season. Moreover, the meteorological data shows that a strongly stable air condition (referred to as the state of G by the Pasquil's stability classification) frequently takes place in the dry season. A stable air condition often results in air pollution staying near the ground surface, thereby resulting in serious ambient air pollution in the dry season. Fig. 3.2 shows the salient characteristics of the climate of Bangkok.

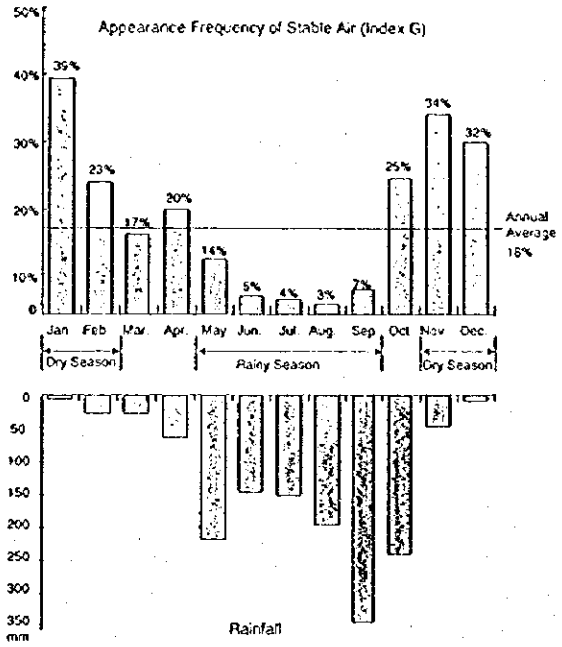


Fig. 3.2 Salient Characteristics of the Tropical Climate of Bangkok

(2) Low Alluvium Plain

The main physiographic features of Thailand are divided into seven regions, namely, the Central Plain, the West Continental Highlands, the North Continental Highland, the Central Highlands, the North Plateau, the Southeast Coast; and Peninsular Thailand.

The Central Plain is a strip of land over 500 Km in length and 100-200 Km in width and this physiographic unit is divided into three areas, namely, the Upper Central Plain, the Nakhon Sawan area and the Lower Central Plain.

The Lower Central Plain covers an area of approximately 53,400 Km^2 and the length from north to south is roughly 200 Km and the average width is approximately 150 Km. The elevation of this Plain range from 20 m above mean sea level (MSL) at Chai Nat in the northern area, 4 - 5 m at Ayutthaya and 1 - 2 m in Bangkok and its vicinities. The Lower Central Plain is a large and flat lowland which is formed by the fluvial process of the Chao Phraya River, the Mae Khlong River, the Tha Chin River and the Bang Pakhong River. These large rivers have been transporting huge volumes of sedimentation for the past several thousands years. Sedimentation takes place mainly at the time of flooding and rivers sometimes freely change the course of channel.

Many abundant river channels can be seen in the lower reach of large rivers in the Lower Central Plain. The geomorphologic map of the Lower Central from the "JICA Study for the Management of Groundwater and Land Subsidence" in 1995 is shown as Fig. 3.3.

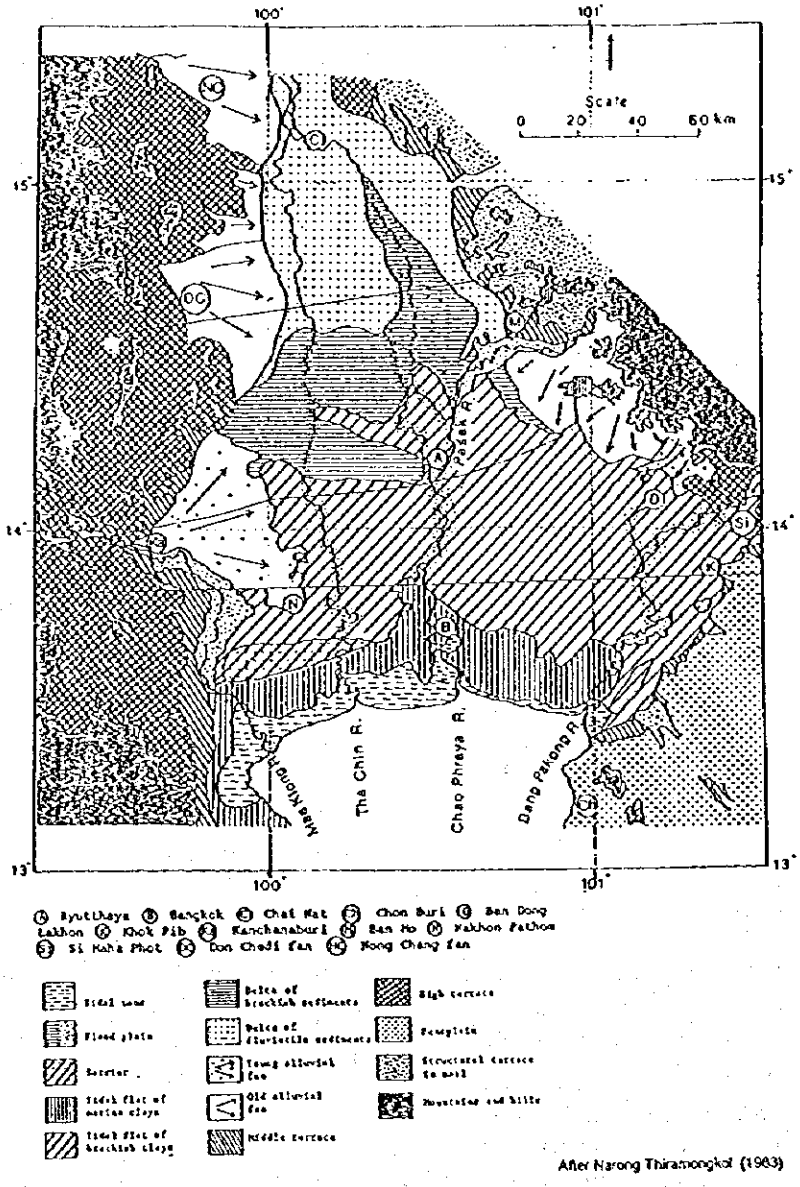
As stated above, Bangkok is located on the low alluvium flat plain of the Chao Phraya River Delta, which belongs to the Lower Central Plain. It is 1 to 2 meters above MSL. Due to these low and flat geographical characteristics, when Bangkok suffers from flooding, it is difficult to drain the water away. It can seriously affect the peoples' life and economy.

(3) Land Subsidence

Rapid urbanization, modernization and industrialization are all demanding more water, however the water supply service can not keep up with the demand. This eventually has increased the groundwater usage, which caused land subsidence. Although land subsidence has now slowed down in the central area of Bangkok as a result of regulation, the suburban areas still receive significant land subsidence, which is

projected at 20 mm/year in Bangkok, and 40 - 55 mm/year in Minburi and Lat Krabang. This could result in serious flood problems in the suburban areas of Bangkok.

According to the simulated land subsidence data by the year 2017, area of less than 50 cm is calculated at 148 km^2 (9.3%), and this area is located in the north-eastern part of BMA such as Minburi and Nong Chok districts.



Source: the Study for the Management of Groundwater and Land Subsidence, JICA, 1995

Fig. 3.3 Geomorphological Map of the Lower Central Plan

946 km^2 (60%) of the area is calculated at 50 cm-100 cm of subsidence and 485 km^2 (31%) of the area is calculated at more than 100 cm of subsidence in the BMA. More than 85% area of the Bangkok Yai, Khlong San, Bangkok Noi. Phasi Charoen, Huai Khwang and Nong Khaem districts are covered by a contour line of subsidence over 100 cm.

Based on the analysis by GIS, it is concluded that Huai Khwang, Khlong Toei, Bangkok Noi and Phra Khanong districts are areas which have a higher potential both of land subsidence and flooding.

Fig 3.4

Problem Areas on Natural Constrainnts

Legend

- Less than -50 cm
- -50 to -75 cm
- -75 to -100 cm
- -100 to -125 cm
- -125 to -150 cm
- More than -150 cm
- Flooded Area in 1983
- Chaopraya River
- Railways
- BMA Boundary
- District Boundary
- Subdistrict Boundary

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KILOMETERS

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(4) Floods

Due to the low alluvium plain, Bangkok has traditionally suffered from floods. In particular, Bangkok suffered heavy damages in 1983 and 1995. The Chao Phraya River recorded the highest water level of 2.27 m MSL at the Memorial Bridge in October in 1995, which is higher than in 1983 (2.13 m) when most of the BMA area suffered from heavy flooding for several days. Floods in 1993 recorded higher water level but damages are limited in narrow areas.

According to the GIS analysis, total flooded area from the 1983 flood in BMA is calculated at 424 km^2 and more than 80 % of districts such as Phra Khanong, Lat Phrao, Suan Luang, and Bang Kapi districts were inundated. 54%-68% of Khlong Toei, Huai Khwang, Jomtong and Prawet districts were inundated. Inundated areas are shown in Fig. 3.4.

(5) Air Pollution

1) Pollutant Sources and Amounts

In the BMR, nearly 50% of the consumption of petroleum products in Thailand occurs. Through consumption of petroleum products, large amounts of air pollutants are emitted continuously. The annual amount of these pollutants by sector is estimated in Table 3.1 and Fig. 3.5.

Table 3.1 Air Pollutants Emissions in BMR, by Sector, 1992

1000 ton/year

Sector	SOx	NOx	CO	PM-10
Power Plant	104	23	2	4
Industry	145	24	7	12
Land Transportation	22	141	686	152
Commercial & residential	0	1	0	0

Source: Power Plant, Industry and Com. & Res.; Air Pollution Database, 1992, PCD
Land Transportation; JICA, BEIP Study Team

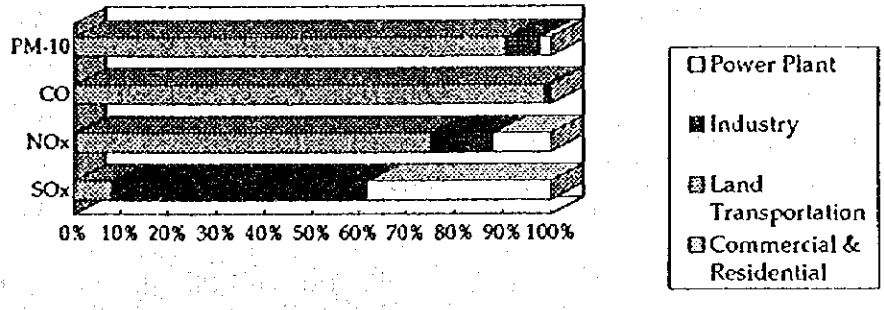


Fig. 3.5 Air Pollutants Emissions Ratio by Sector, BMR, 1992

The emissions from land transportation accounts for a very large portion of NOx, CO and PM-10. The emissions from vehicles contributes a significant, although not the highest, portion of SOx.

It is noteworthy that the emissions from land transportation have a direct affect on the concentration of ground level pollutants. In addition, the stable condition of the atmosphere increases the ground level concentration.

2) Monitoring Result of Pollutants

Currently, PCD is monitoring the ambient air condition of the entire nation, with 8 stationary monitoring stations in 1994 (as shown in Fig. 3.6 and 7), and approximately 15 temporary monitoring stations in Bangkok. The Ministry of Health operates 3 stationary monitoring stations in Bangkok under the UNEP-WHO Global Environmental Monitoring System. The Department of Health, BMA, has one stationary monitoring station.

Nevertheless, the ambient air quality standard was formulated to protect the people's health. It is therefore essential to review the results of the monitored ambient air condition with respect to the air quality standard.

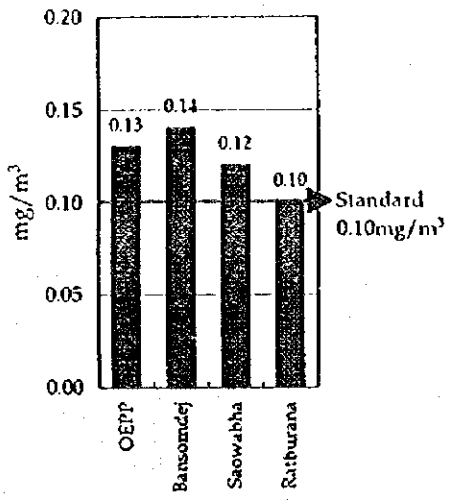
Ambient air quality standards and the PCD's monitored ambient air condition results of 1994 are summarized in Table 3.2. This table implies issues listed below.

Table 3.2 Review of the Present Situation of the Atmosphere, 1994

Pollutant	Evaluating Time	Standard Value	Roadside	General Area
CO	1 Hour	50 mg/m3	0/18	0/4
	8 Hours	20 mg/m3	2/18	0/4
NO2	1 Hour	0.32 mg/m3	-	-
SO2	1 Hour	0.78 mg/m3	-	-
	24 Hours	0.30 mg/m3	-	-
	1 Year	0.1 mg/m3	-	-
TSP	24 Hours	0.33 mg/m3	12/15	2/4
	1 Year	0.10 mg/m3	-	3/4
PM-10	24 Hours	0.12 mg/m3	2/2	-
	1 Year	0.05 mg/m3	-	-
O3	1 Hour	0.20 mg/m3	-	-
Lead	24 Hours	10 µg/m3	0/15	0/4

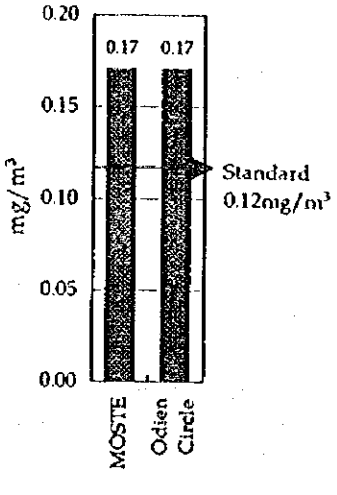
Source : Management of Air Pollution and Noise Pollution in 1993-1994, PCD
Notes : Ex. 2/15 means 2 stations value of 15 stations exceed the air quality standard.
_I_I_I column means no available data.
Standard values were valid value as of 1994.

First, many stations exceeded the standards for TSP and PM-10. In Fig. 3.6 and 3.7, TSP and PM-10 numerical data are graphed. Briefly, PM-10 indicates suspended dusts below 10 micron diameter and TSP indicates whole suspended dusts. For the health of the people of Bangkok, the mitigation of this high concentration of TSP and PM-10 is an urgent issue.



Source: Management of Air Pollution and Noise Pollution in 1993 - 1994, PCD

Fig. 3.6 TSP, One Year Average 1994, General Stations



Source: Same as Fig. 3.6

Fig. 3.7 PM-10, Max. of 24 Hr Ave. 1994, Roadside Stations

It is said that PM-10 consists of two portions. One is of natural origin such as the fine matters of soil or sea-salt particulates, and the other is human activity origin matter. For human activity origin PM-10, particulate matters from vehicle exhaust pipe and stationary source stacks might be typical. PM-10 is inhalable and affects human health.

TSP consists of PM-10 and other coarse particles, exceeding 10 microns in diameter. It might be supposed that construction activities on and around roads, and vehicles traveling on dusty roads, are major sources of the coarse portion of TSP. In addition to scattered dust from vehicle tires, body and truck beds might belong to the coarse portion and worsen the TSP concentration.

Integrated abatement measures of the above-mentioned sources should be implemented urgently, not only for PM-10 but also for TSP.

Second, mitigating the level of CO is another target. One hour values are under the standard, however the roadside 8 hours average exceeds the standard at some roadside stations. Vehicles are thought to be the cause, and vehicle traffic is expected to increase in the future. Regulations with regard to CO from vehicles may be necessary.

Third, there are many loopholes for reviewing the current atmospheric pollution. The monitoring activity is not sufficient. SO_2 and NO_2 were not monitored in 1994. PCD has already started monitoring SO_2 and NO_2 at several stations. This activity should be strengthened to monitor not only the residential areas, but also roadside areas. These areas should be monitored as many inhabitants earn their living at roadside areas in Bangkok. In addition, PCD started monitoring O_3. If these monitoring data are reviewed analytically, the significant characteristics of pollution in Bangkok could be understood.

3) Method of Current Air Pollution Simulation

To review the present condition, the simulation analysis of air pollutants is introduced. SOx, NOx, CO and PM-10 emissions from vehicles, which are believed to be the major source of pollution, are examined, and their ground level concentrations are simulated.

The concentration distribution patterns simulated by the model are shown below. The ranking for each air pollutant is determined by statistical analyses between the standards and the arithmetic annual average of hourly data measured in Bangkok (PCD, 1995) and Samut Prakan (JICA, 1991).

Grids where CO exceeds the standards are limited to several grids along major roads in inner Bangkok. There is no contradiction between this simulation result and the monitoring result by PCD, i.e. exceeding CO standard points are only 2 out of 18.

On the other hand, there were many grids with a PM-10 concentration "extremely" exceeding the standard in the result of this simulation. According to the PCD data, however, the concentration levels of PM-10 in terms of the annual geometric means were 1.3 to 1.5 times the standard, while the simulated levels at the grids where the PCD stations are located are all categorized as "extremely higher than the standard".

This implies that there may be a possibility of over-estimation for the emission factors used by the simulation. This question will be clearer after the on-going review of emission factors by PCD, supported by the World Bank, is completed. However, even if the emission factors of this simulation model are assumed to be half, the grids evaluated at "extremely higher than the standard" would fall into the category of "higher than the standard" which would still significantly exceed the standard. The grids are spread over the area of Bangkok.

For NO_2, the area "higher than the standard" is widely spread. Thus, most Nox are believed to originate from vehicles.

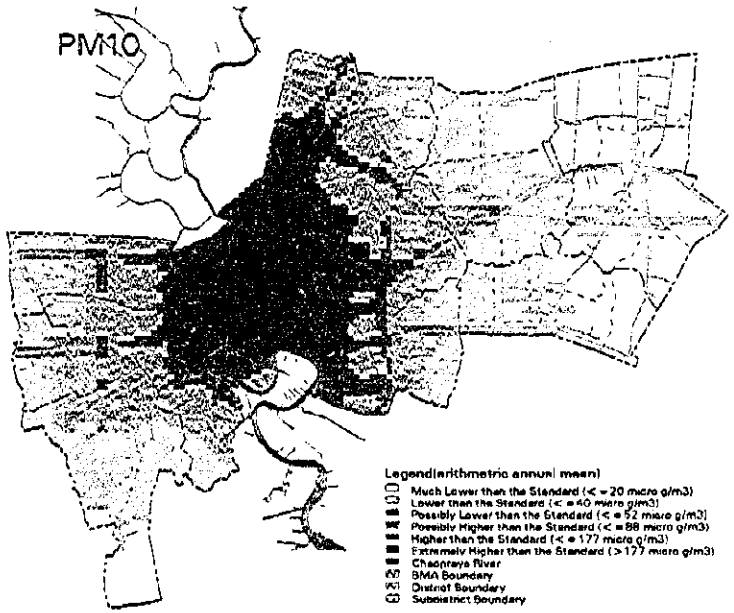
For SO_2, the simulation, which considers only vehicle sources, implies that all regions except 8 km_2 are "lower than the standard". However, in the simulation shown in Fig. 3.8 that includes effects of some power plants, "possibly higher than the standard" and "higher than the standard" zones appear significantly. Influence of power plants might therefore be an important factor for this pollutant.

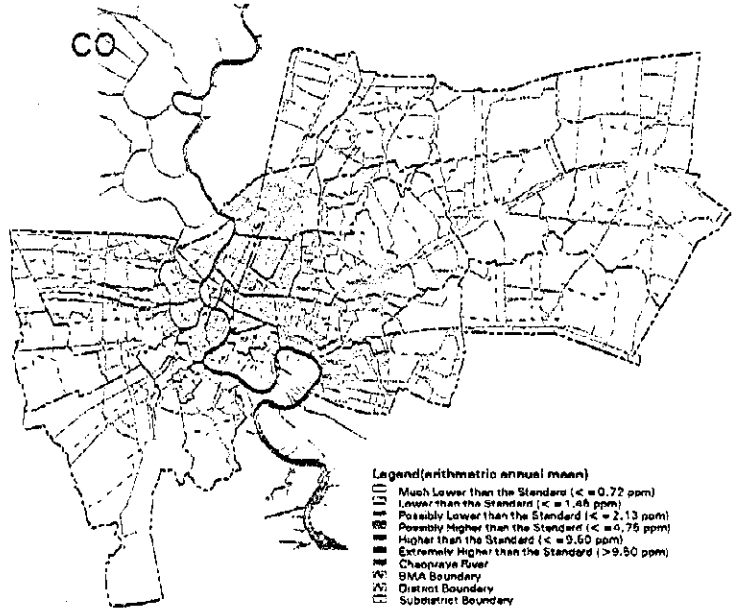
Substantial monitoring of NO_2 and SO_2 has started recently. Hence, comparison of results between the monitoring and the simulation is not possible at the present time.

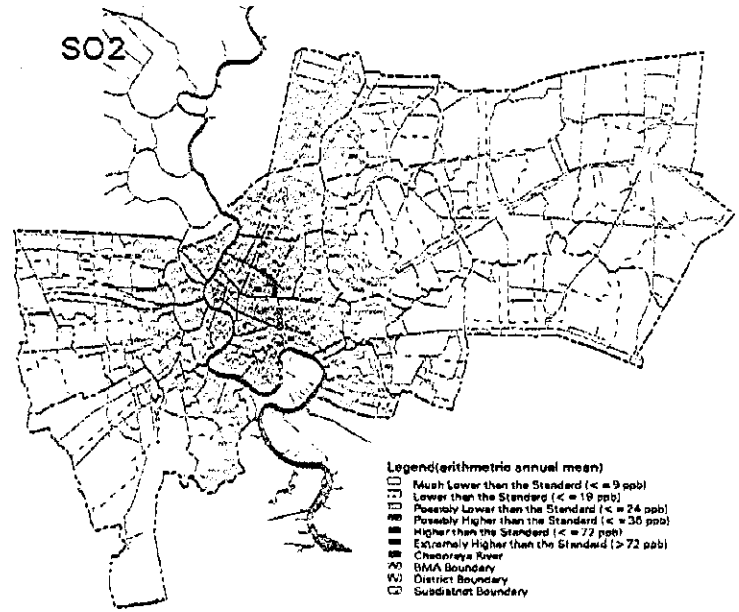
Air Pollution Simulation

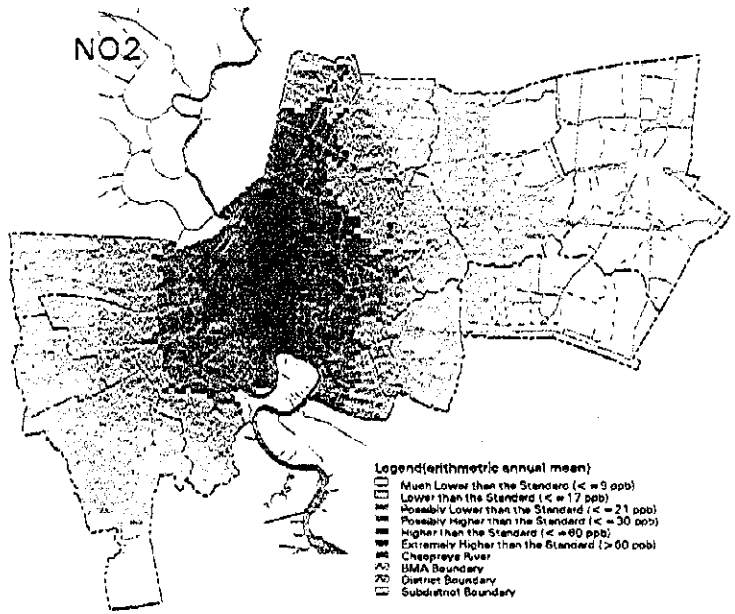
Case 1

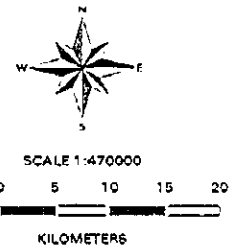
Present Vehicle Emission Factor
Present Road Network
Present Mass Transit Network
Present Transport Demand











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(6) Water Quality

The contaminated Khlong water areas extends considerably in the BMA area, from the Khlong Lad Phrao to Khlong Phra Khanong line to the west of the Bangkok side and from the Khlong Bangkok Yai to Chom Thong and Rat Burana Districts line to the east of the Thonburi side, which shows progressively contaminated water of 20 to 40 mg/lit in BOD and 0 to 2 mg/lit in DO. Aquatic life along the city khlongs has almost disappeared in the central part of the city.

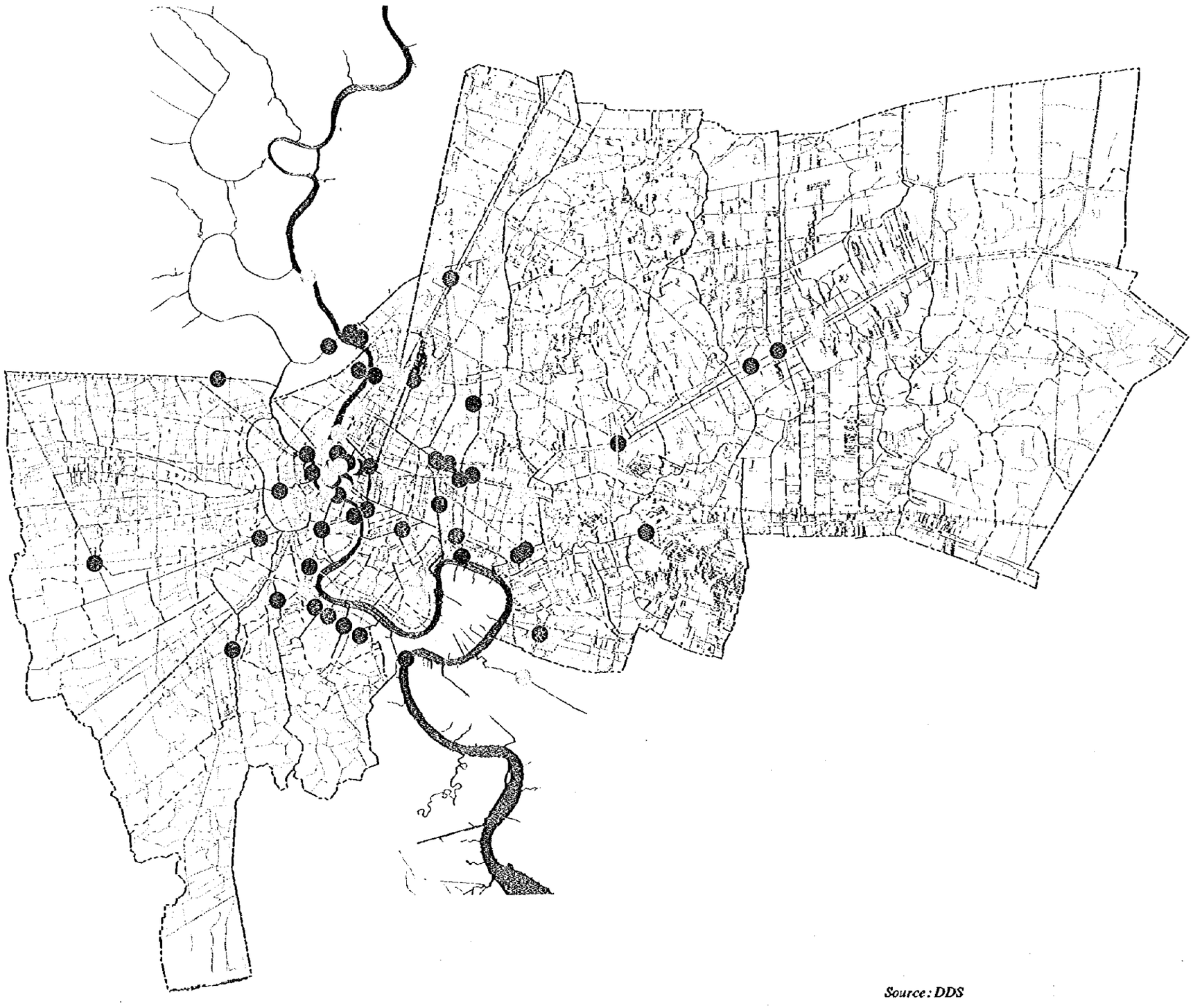
Water contamination in the recent years shows signs of slight improvement in the khlong water. On the contrary, the water quality in the Chao Phraya River shows 3 to 4 mg/lit in BOD off shore of the Khlong Phra Khanong estuary.

Water quality in the khlongs must be improved for water transportation, tourism water life by the citizen of Bangkok.

(7) Green Distribution

Green areas are analyzed by the Landsat data. In the built-up areas, there are few large greens areas except parks and open spaces. Green areas seem to exist mainly on private property. However, in the suburban area, relatively large green areas remain along the channels, development is causing their disappearance.

Water Quality (Contaminated Area)



Legend

- Klong Water Contaminated Area
- Chaopraya River
- River/Khlong
- Rail
- Road
- BMA Boundary
- District Boundary
- Subdistrict Boundary
- More than 40 mg/l
- 30 to 39 mg/l
- 20 to 29 mg/l
- Less than 20 mg/l

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SCALE 1:235000

5 0 2 4 6 8 10

KILOMETERS

Source : DDS

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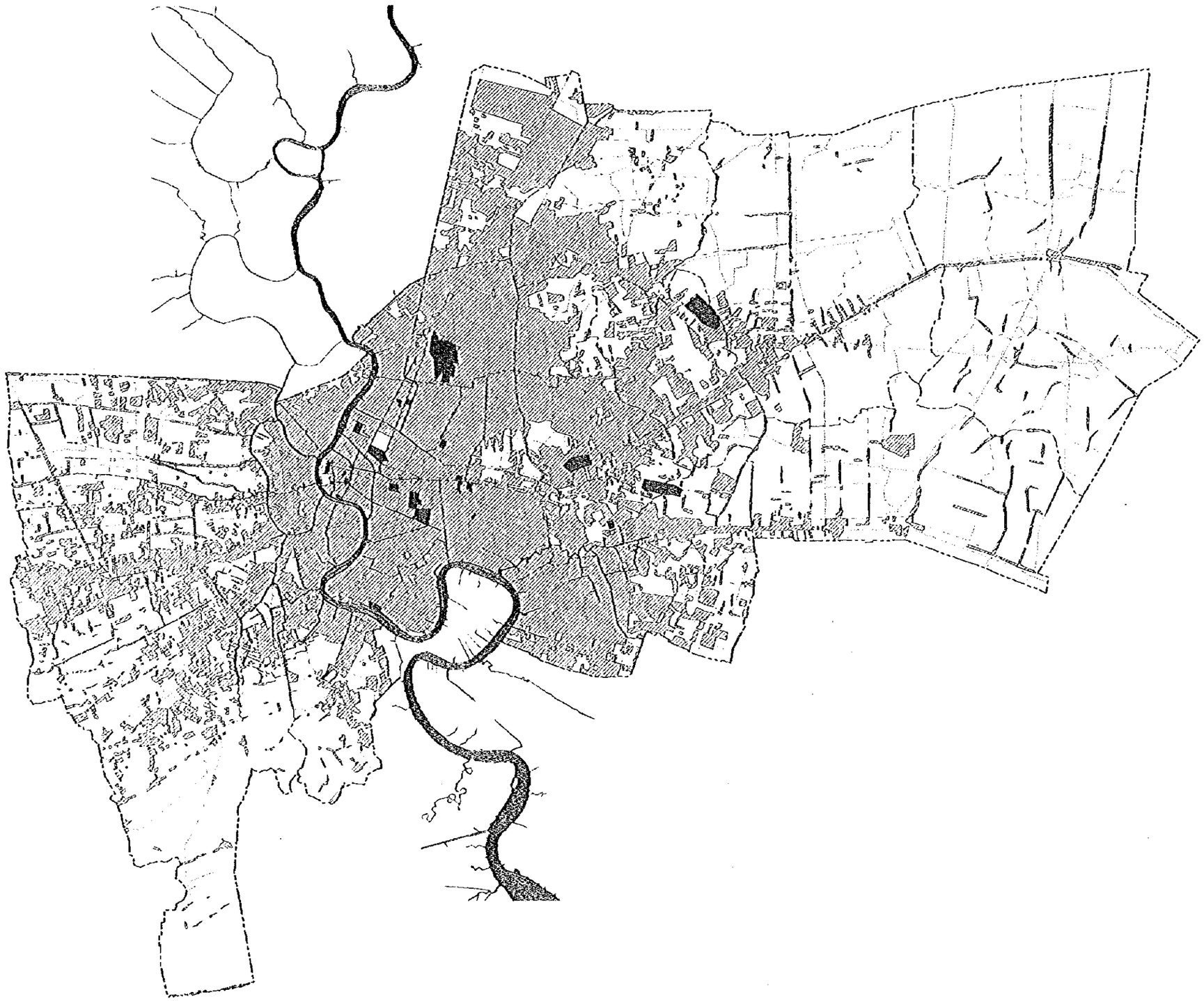

Green Coverage
(Except for Cultivated Land, Interpreted from Landsat TM Data)

Legend

- Build-up Area
- Vegetated Area
- Park
- Chaopraya River
- BMA Boundary
- District Boundary
- Subdistrict Boundary

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3.3 Urban Transport

(1) Person Trip Production and Pattern in BMA

A total of 21.3 million person trips are made by 11.5 million people on a typical day in the BMR. A trip production rate of BMR in gross terms (production rate divided by the total population) is estimated at 1.86[1]. Approximately 82 % of these trips have either their origins or destinations within BMA (hereafter termed "BMA related trips"). In addition, more than 90 % of these trips have both the starting- and ending-point within BMA (termed "Intra-BMA Trips). Inbound- and outbound-trips to/from BMA are quite small, estimated at approximately 8.8 % of the BMR total trips. It seems reasonable to suppose that **BMA is a relatively closed area in terms of the daily travel of the people.**

Accordingly, it should be kept in mind that traffic problems in Bangkok are simply caused by the social and economic activities of Bangkok, and not from those living outside BMA. Bangkokians are thus suffered from the problems caused by themselves. The following question could be raised: should the problem be solved within Bangkok, or through utilization of resources outside Bangkok, or both?.

Table 3.3 Person Trip Production by Mode, by Purpose (linked trips)

a)INTRA BMA MORNING TRIPS (6:00 - 10:00AM)

Mode	Purpose-Persons HBW	HBE	HBO	NHB	TOTAL	%
Walk	232,714	366,676	209,157	56,997	865,545	12.6%
	9.93%	23.20%	11.22%	5.40%	12.65%	
M/C	437,021	147,317	512,830	239,479	1,336,647	19.5%
	18.65%	9.32%	27.51%	22.67%	19.53%	
Car	556,931	155,050	607,681	698,919	2,018,581	29.5%
	23.77%	9.81%	32.59%	66.16%	29.49%	
PT	1,116,732	911,275	534,794	60,997	2,623,798	38.3%
	47.65%	57.66%	28.68%	5.77%	38.33%	
Total	2,343,398	1,580,318	1,864,462	1,056,393	6,844,570	100.0%
	34.24%	23.09%	27.24%	15.43%	100.00%	

Source: BEIP/UTDM Home Interview Survey

b) FROM BMA TO OUTSIDE TRIP (MORNING)

Mode	Purpose-Persons HBW	HBE	HBO	NHB	TOTAL	%
Walk	2,157	723	0	0	2,879	0.8%
	1.33%	1.27%	0.00%	0.00%	0.83%	
M/C	23,295	2,051	2,216	13,401	40,963	11.8%
	14.38%	3.61%	4.09%	17.94%	11.78%	
Car	53,054	10,591	29,750	51,845	145,239	41.8%
	32.74%	18.67%	54.91%	69.42%	41.78%	
PT	83,534	43,373	22,211	9,439	158,556	45.6%
	51.55%	76.44%	41.00%	12.64%	45.61%	
Total	162,040	56,738	54,177	74,685	347,637	100.0%
	46.61%	16.32%	15.58%	21.48%	100.00%	

Source: BEIP/UTDM Home Interview Survey

[1] According to the Study on Medium- to Long- term Improvement / Management Plan of Road and Road Transport in Bangkok by JICA, the trip production rate is estimated at 2.22 in gross terms (rate against the population consisting of those age 6 and above).

c) FROM OUTSIDE TO BMA TRIP (MORNING)

Mode	Purpose-Persons HBW	HBE	HBO	NHB	TOTAL	%
Walk	0	0	0	0	0	0.0%
	0.00%	0.00%	0.00%	0.00%	0.00%	
M/C	33,567	3,315	7,508	3,784	48,174	13.9%
	19.65%	4.76%	10.80%	10.64%	13.94%	
Car	65,281	11,558	44,699	29,026	150,564	43.6%
	38.22%	16.61%	64.31%	81.58%	43.58%	
PT	71,955	54,727	17,300	2,768	146,750	42.5%
	42.13%	78.63%	24.89%	7.78%	42.48%	
Total	170,803	69,600	69,507	35,578	345,489	100.0%
	49.44%	20.15%	20.12%	10.30%	100.00%	

Source: BEIP/UTDM Home Interview Survey

d) MORNING TRIP WHICH HAS ITS ORIGIN OR DESTINATION IN BMA

Mode	Purpose-Persons HBW	HBE	HBO	NHB	TOTAL	%
Walk	234,871	367,399	209,157	56,997	868,424	11.5%
	8.78%	21.53%	10.52%	4.89%	11.52%	
M/C	493,883	152,683	522,554	256,664	1,425,785	18.9%
	18.45%	8.95%	26.28%	22.00%	18.92%	
Car	675,266	177,199	682,130	779,790	2,314,384	30.7%
	25.23%	10.38%	34.31%	66.84%	30.70%	
PT	1,272,221	1,009,375	574,305	73,204	2,929,104	38.9%
	47.54%	59.14%	28.89%	6.27%	38.86%	
Total	2,676,241	1,706,656	1,988,146	1,166,656	7,537,696	100.0%
	35.50%	22.64%	26.38%	15.48%	100.00%	

Source: BEIP/UTDM Home Interview Survey

e) INTRA-BMA TRIPS (ALL DAY)

Mode	Purpose-Persons HBW	HBE	HBO	NHB	TOTAL	%
Walk	631,539	766,952	481,135	112,775	1,992,401	12.8%
	10.9%	21.6%	11.9%	5.2%	12.8%	
M/C	1,056,735	299,310	981,123	450,581	2,787,749	17.9%
	18.24%	8.42%	24.28%	20.93%	17.94%	
Car	1,297,121	303,490	1,301,277	1,268,848	4,170,736	26.8%
	22.4%	8.5%	32.2%	58.9%	26.8%	
PT	2,809,052	2,183,071	1,276,633	320,680	6,589,436	42.4%
	48.5%	61.4%	31.6%	14.9%	42.4%	
Total	5,794,447	3,552,823	4,040,168	2,152,884	15,540,322	100.0%
	37.3%	22.9%	26.0%	13.9%	100.0%	

Source: BEIP/UTDM Home Interview Survey

f) FROM BMA TO OUTSIDE TRIP (ALL DAY)

Mode	Purpose-Persons HBW	HBE	HBO	NHB	TOTAL	%
Walk	2,157	877	3,019	461	6,514	0.7%
	0.5%	0.6%	1.7%	0.2%	0.7%	
M/C	58,412	5,675	16,177	16,263	96,528	10.2%
	13.7%	3.7%	8.9%	8.7%	10.2%	
Car	148,440	22,664	103,835	132,164	407,103	43.0%
	34.8%	14.8%	56.9%	71.0%	43.0%	
PT	217,136	123,521	59,360	37,334	437,351	46.2%
	51.0%	80.9%	32.5%	20.0%	46.2%	
Total	426,145	152,738	182,391	186,222	947,496	100.0%
	45.0%	16.1%	19.2%	19.7%	100.0%	

Source: BEIP/UTDM Home Interview Survey

g) FROM OUTSIDE TO BMA (ALL DAY)

Mode	Purpose-Persons HBW	HBE	HBO	NHB	TOTAL	%
Walk	2,157	723	3,019	461	6,359	0.7%
	0.5%	0.5%	1.4%	0.3%	0.7%	
M/C	64,398	5,759	19,630	11,163	100,950	10.7%
	14.9%	3.8%	9.2%	7.9%	10.7%	
Car	150,735	24,575	133,737	105,872	414,919	44.1%
	34.8%	16.0%	62.8%	74.7%	44.1%	
PT	215,927	122,128	56,439	24,308	418,802	44.5%
	49.8%	79.7%	26.5%	17.1%	44.5%	
Total	433,217	153,185	212,825	141,804	941,030	100.0%
	46.0%	16.3%	22.6%	15.1%	100.0%	

Source: BEIP/UTDM Home Interview Survey

h) WHOLE BMR (ALL DAY)

Mode	Purpose-Persons HBW	HBE	HBO	NHB	TOTAL	%
Walk	752,663	942,036	538,722	134,798	2,368,219	11.1%
	9.3%	20.1%	9.7%	4.5%	11.1%	
M/C	1,644,751	425,571	1,431,913	635,305	4,137,540	19.4%
	20.3%	9.1%	25.9%	21.1%	19.4%	
Car	1,923,772	431,060	1,987,093	1,835,642	6,177,567	28.9%
	23.7%	9.2%	35.9%	61.1%	28.9%	
PT	3,784,851	2,894,348	1,576,403	400,522	8,656,125	40.6%
	46.7%	61.7%	28.5%	13.3%	40.6%	
Total	8,106,037	4,693,016	5,534,132	3,006,266	21,339,451	100.0%
	38.0%	22.0%	25.9%	14.1%	100.0%	

Source: BEIP/UTDM Home Interview Survey

Morning (starting between 6:00 - 10:00 AM) person trips according to four main purposes and by mode are presented in Table 3.3 a) - d) and daily trips in the same form are presented in Table 3.3 e) - g). Table 3.3 h) shows daily person trips of BMR.

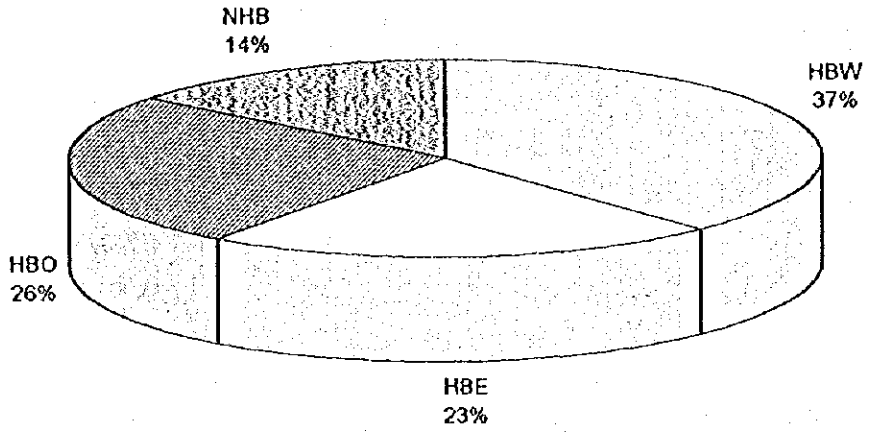
From Table 3.3 e), it is found that **Daily Home-Based Work (HBW) trips are the dominant (37.3%), followed by Home-Based Education (HBE) trips (22.9%).** A combination of these two types of trips equals approximately 60 % of the total daily trips.

The transport mode for daily intra-BMA trips is predominantly private transport, accounting for approximately 45% of the total (including 27% for private cars and 18% for motorcycles), followed by the public transport mode (42%).

The representative mode for HBW is the public transport mode, accounting for approximately 49% of the total HBW trips. **However, approximately 40 % of HBW trips are made by private transport mode.**

The mode for HBE is mainly dominated by the public transport mode, estimated at approximately 61% of the total HBE trips. The private transport users for this trip is not so significant.

Non-Home Based trips, which seem to consist chiefly of business trips, are mainly made by private cars (60 % of the total trips are that purpose). This implies that business trips are predominantly undertaken where there is no effective or quality public transport.



Source: BEIP/UTDM Home Interview Survey

Fig. 3.11 Journey Purpose of BMA Intra Trips

(2) Person Trip Length by Mode of Transport

The trip lengths of HBW and HWE trips are indicators for identifying the extent of the commuting area. Table 3.4 shows the average linked-trip distances by purpose and by representative mode for travel.

According to the UTDM travel speed survey, the average a.m. peak travel speed for cars within the Middle Ring Road was 15 km/h and 11 km/h for buses.

The estimated average trip lengths are around 10 km except the private vehicle trips for the HBW purpose. If a 10 km trip is made within 30 to 45 minutes (this time period seems to be a reasonable commuting time), the average travel speed would be increased to 13 to 20 km/h for a typical commute in Bangkok.

From the difference between the observed travel speed and a preferred travel speed of a typical commute, a target transport policy can be set forth with an increase of 2 to 9 km/h within the Middle Road System. In addition, road segments where average speeds are less than 20 km are identified as focal segments of the road system to be improved in Bangkok.

It is important to note that **the private vehicle trips of HBW are rather long, at an average of approximately 15 km.** The most likely explanation for this is that people with cars prefer to live in suburban areas where there are less effective public transport services. Recently, housing development in the suburbs of Bangkok is rapidly expanding, thus a significant increase of long distance HBW trips is easily anticipated in the near future.

Within this context, it is a debatable point whether it is still necessary to accelerate the radial-type road construction which would be beneficial especially to those who select the suburbs for their area of residence, or whether a ring-type arterial road at the fringe of the existing built-up area and/or secondary systems which will be beneficial for cargo and business trips should be accorded high priority for development. Housing development, which has less impact onto the existing system, should be discussed further.

Table 3.4 Average Trip Distance by Mode by BMA Residents

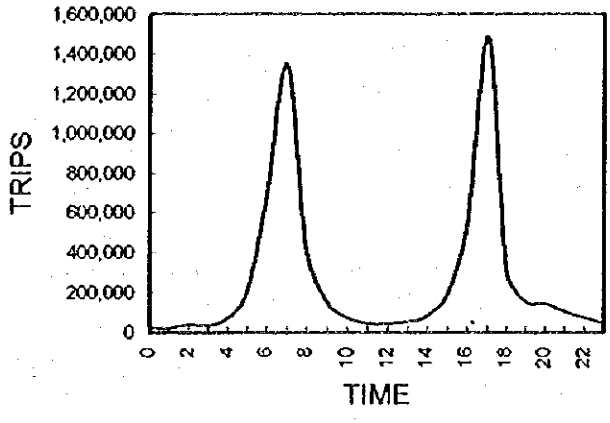
MODE	HBW	HBE	HBO	NHB
MC	11.5 km	7.7 km	6.1 km	9.7 km
CAR	15.2 km	10.5 km	9.1 km	9.7 km
Public Transport	11.5 km	9.6 km	8.4 km	13.0 km
Average	12.4 km	9.1 km	7.9 km	9.7 km

Source: BEIP/UTDM Home Interview Survey

(3) Time of Travel

Through analyses of the BEIP/UTDM Home Interview Survey, it is found that a **predominant proportion (40 %) of HBW trips start during the period 6:00 a.m. to 10:00 a.m.** This clearly explains the traffic congestion which is usually observed between 7:00 am and 9:00 on many of the major road segments.

A transport policy should focus on this transport demand and should seek measures to accommodate this demand from a short-term point of view.



Source: BEIP/UTDM Home Interview Survey

Fig. 3.12 Travel Staring Time of HBW Trip in BMA

(4) Travel Mode and Journey Purpose in the Morning Peak Hour

Approximately 30% of the morning trips made between 6:00 am and 10:00 am are vehicular trips, which is estimated to be 2.3 million trips a day. According to the UTDM survey, the vehicle occupancy rate for a car ranges 1.22 to 1.48. Based on these figures, it is calculated that 390,000 - 475,000 private vehicles are started during one hour of the morning. If this figure is multiplied by 10m (space for vehicles), demand for the road system in a morning hour is calculated at 1950 km - 2375 km (two-lanes), which can be as much as 103 to 126 % of the major arterial system within BMA in terms of length (1880 = 2*990 km by OCMRT's classification).

If the present situation of job locations and transport services is given, this excessive demand should be re-allocated to a different time period in order to release the excessive dependency on the road system. For example, a staggered commuting hours system needs to be seriously discussed by each private company and

the modal shift of the use of private vehicles for HBW and HBE (approximately 11% of the total morning trips) to use of public transport should be encouraged. If all the HBW and HBE trips made by private car are shifted to the public transport system, approximately 38% of the total car trip demand can be removed from the road segments. However, there will still remain a 1209 km - 1,473 km (two-lanes) demand on the road system against the existing arterial road system in the peak hour.

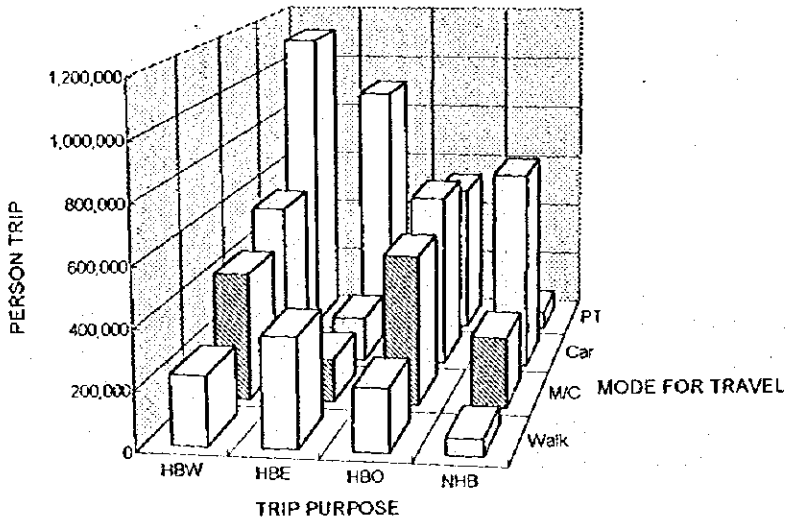


Fig. 3.13 Linked Intra BMA Trip by Mode and by Purpose

(5) Mode Choice, Vehicle Ownership and Income

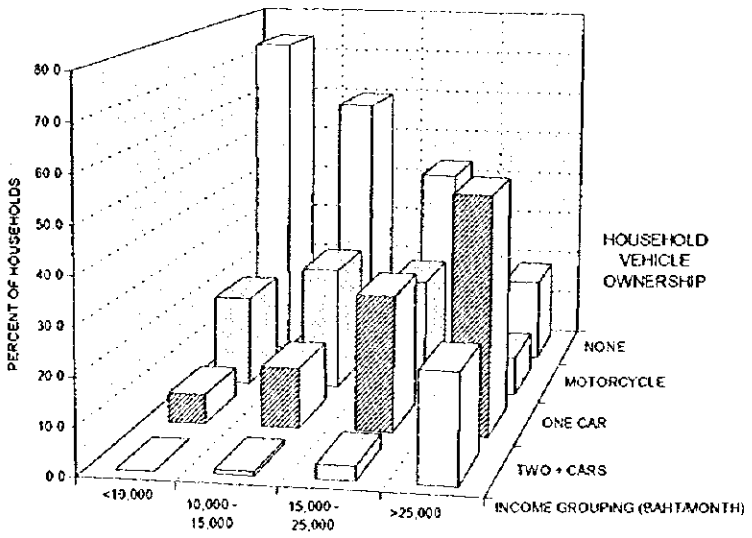
Table 3.3 shows the relationship between vehicle ownership and choice of mode for transport. Obviously, a high percentage of the choice for vehicles is observed in a household vehicles. Looking at this table with the relationship presented in Fig. 3.14, it is safe to say that an increase of household income will easily lead to an increase of private vehicular trips.

Based on the Household Interview Survey and other economic indicators, an average household income for the year 2011 is estimated to be 34,000 baht / month in 1995 constant prices. Since the elasticity of vehicle ownership growth rate to income growth rate has proved to be 1.0 or slightly over 1.0, the vehicle ownership will undoubtedly increase at 1.6 times or more in 1995.

Table 3.5 Vehicle Ownership and Choice of Mode

VEHICLE OWNERSHIP	WALK	PRIVATE VEHICLE MC	PRIVATE VEHICLE CAR	PUBLIC TRANSPORT
NONE	21.3%	6.5%	2.2%	69.9%
MC	21.7%	42.1%	2.1%	34.1%
1 CAR	18.7%	9.7%	41.9%	29.8%
2+CAR	14.0%	5.9%	62.7%	17.3%

NOTE: VEHICLE OWNERSHIP
NONE : NO PRIVATE VEHICLE AVAILABLE
MC : AT LEAST ONE MOTOR CYCLE
1 CAR : ONE CAR AND POSSIBLY A MOTORCYCLE
2+CAR : TWO OR MORE CAR AND POSSIBLY A MOTOR CYCLE
CAR INCLUDES VANS, SEDANS OR SIMILAR VEHICLES.



Source : BEIP / UTDM Home Interview Survey

Fig. 3.14 Vehicle Ownership and Household Income

(6) Trip Generation and Attraction Density in BMA

Fig. 3.15 shows the total trip production density (all day - all purpose person trip divided by area) and Fig. 3.6 shows the total trip attraction density. The former indicates the residential areas, the latter indicates those in attraction centers such as business and commercial center and large industrial estates.

In the production density map, several high production zones can be found at Ratchathewi, Pathumwan, Bang Rak, Khlong Toei (North of Sukhumvit Rd.), Phaya Thai, and Part of Bang Sue. These trip production centers have a high population density as well.

The location of these high production zones are limited to within a radius of about 5 km from the Democracy Monument.

Attraction zones can be found at Phra Nakhon, Pom Prap Sattruphai, the old town of Samphanthawon, Bang Rak, Pathumwan and Ratchathewi. These are located in the areas east of Chao Phraya River and west of the Chalerm Mahanakhon Expressway. Other notable attraction zones are observed at Din Daeng, Chatuchak, Minburi and Khlong Toei (along the Sukhumvit Rd.).

Bang Khen, Minburi, and Muang Nontaburi does not have a high attraction density ratio, however, they have a high attraction trip volume.

The old town surrounding Phara Nakhon has been developed with an adequate secondary road system, however, the road densities of the other attraction centers are relatively low.

Therefore, in order to create quality urban areas it is necessary to develop secondary road systems as found in the old town. In this regard, east of Rama VI Rd, north of Sathorn, Khlong Toei, Phaya Thai, Huai Khwang, and east of Thonburi should be studied.

Fig. 3.15

Daily Traffic Generation Density

Legend

- Chaopraya River
- 0 to 5000
- 5000 to 10000
- 10000 to 20000
- 20000 to 30000
- 30000 to 40000
- 40000 to 60000
- 60000 to 80000
- 80000 to 100000
- 100000 to 150000
- More than 150000
- Traffic Analysis Zone
- BMA Boundary

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Fig. 3.16

Daily Traffic Attraction Density

Legend

- Chaopraya River
- 0 to 5000
- 5000 to 10000
- 10000 to 20000
- 20000 to 30000
- 30000 to 40000
- 40000 to 60000
- 60000 to 80000
- 80000 to 100000
- 100000 to 150000
- More than 150000
- Traffice Analysis Zone
- BMA Boumrary

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(7) Trip Attraction Centers and Trip Patterns

Computing the "Daytime - Nighttime Population Ratio Distribution" as shown in Fig. 3.16 and Fig. 3.17, which indicates the area distribution of trip attraction density, several relatively major attraction centers can be observed in Bangkok. In Fig. 3.7, the major attraction trips (70 % of the top major attraction trips) entering each attraction center are plotted. Through these diagrams, major commuting attraction centers are identified.

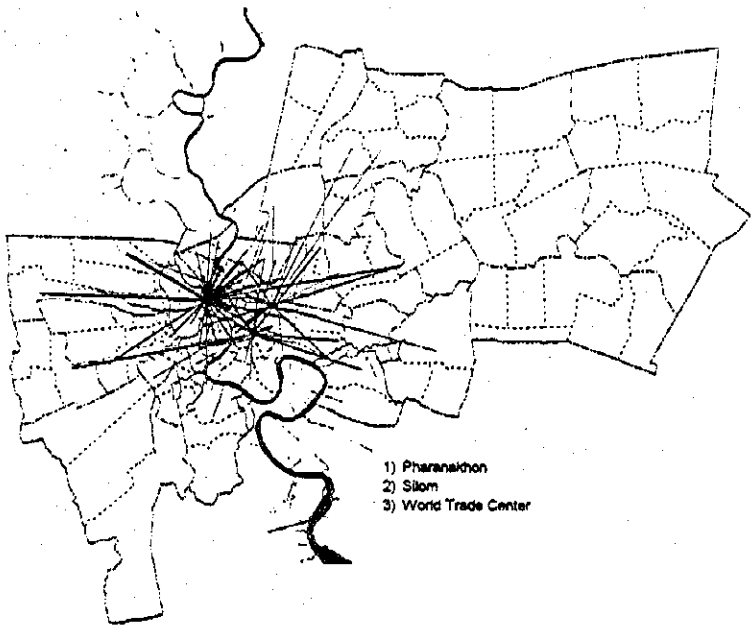
The Silom area, the World Trade Center, and such places known as business/ commercial centers have relatively large commuting areas. These commuting areas are extended notably northward with a radius of approximately 20 km. There are several radial arterial systems which can accommodate such extended commuting areas such as the First and Second Expressway, Wiphawadi Rangsit Rd., Ramkhamhaeng Rd., Sukhumvit Rd. Rama II Rd., Phet Kasem Rd. and Phara Pin Klao Rd.

There are also relatively small commuting areas identified at suburban (local) centers such as Minburi and Romklao. These centers have no significant relationship with the business/commercial and the government center (Phara Nakorn) with regards to movement of people.

(8) Accessibility to the City Centers

Fig. 3.18 shows the difference of travel time between the unloaded case and the loaded case in case of traveling to one of the city centers : the Hua Lamphong Station. In the unloaded case, that is before congestion, the area of travel duration of 45 minutes extends to approximately 20 to 30 km from the center, however, in the loaded case (congested case) the radius of 45 minutes decreases to approximately 5 to 10 km.

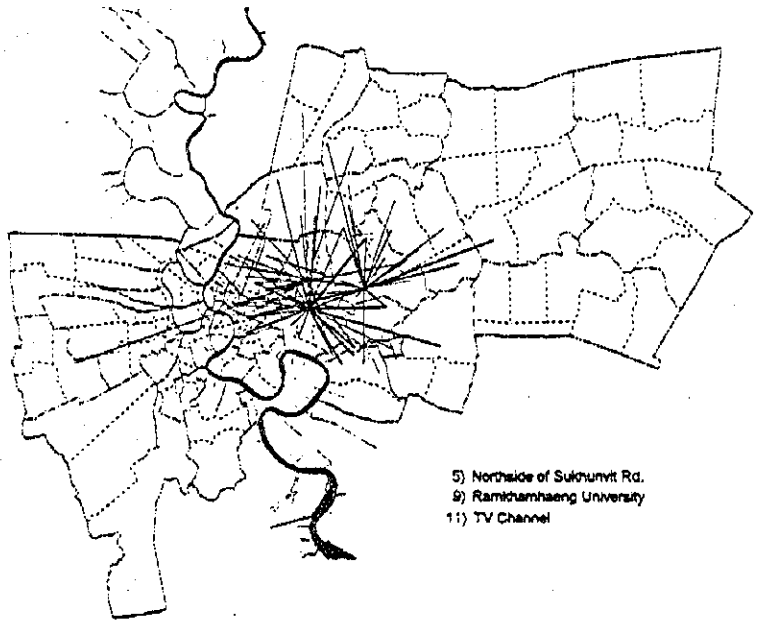
Center Analysis

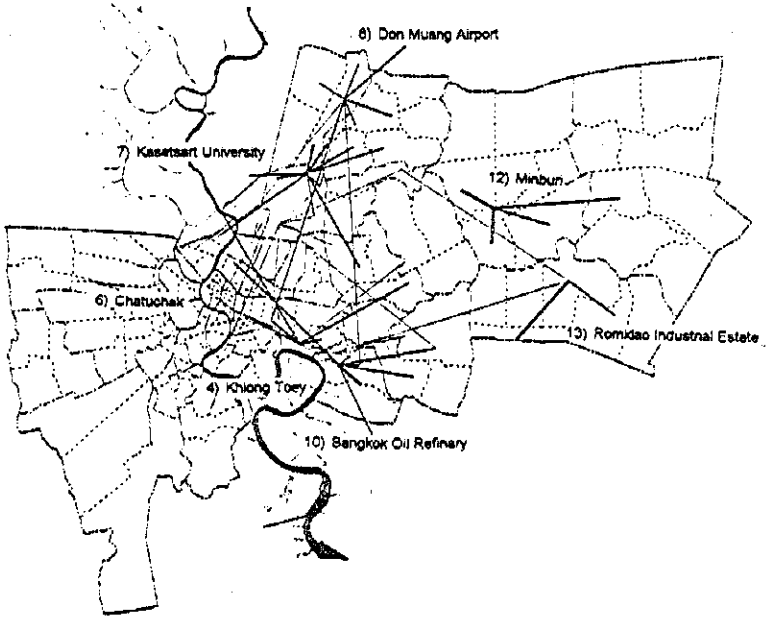


ACCESSIBILITY TO ATTRACTION CENTERS

Centers	Average Distance of Attraction Trips	Accesibility Index
1) Pharanakhon	10.8	1.73
2) Silom	9.3	2.14
3) World Trade Center	11.0	1.82
4) Khlong Toey	10.9	1.66
5) Northside of Sukhunvit Rd.	12.3	1.61
6) Chatuchak	18.9	1.57
7) Kasetsart University	10.8	1.80
8) Don Muang Airport	17.3	1.71
9) Ramkhamhaeng University	14.6	1.77
10) Bangkok Oil Refinary	6.8	2.16
11) TV Channel	12.4	1.51
12) Minburi	10.1	1.57
13) Romklao Industrial Estate	17.0	1.23

NOTE : Accesibility Index = Travel Time of Loaded / Travel Time of Unloaded Road





Legend

- Chopraya River
- Rank 1
- Rank 2
- Rank 3
- Rank 4
- BMA Boundary
- District Boundary
- Subdistrict Boundary

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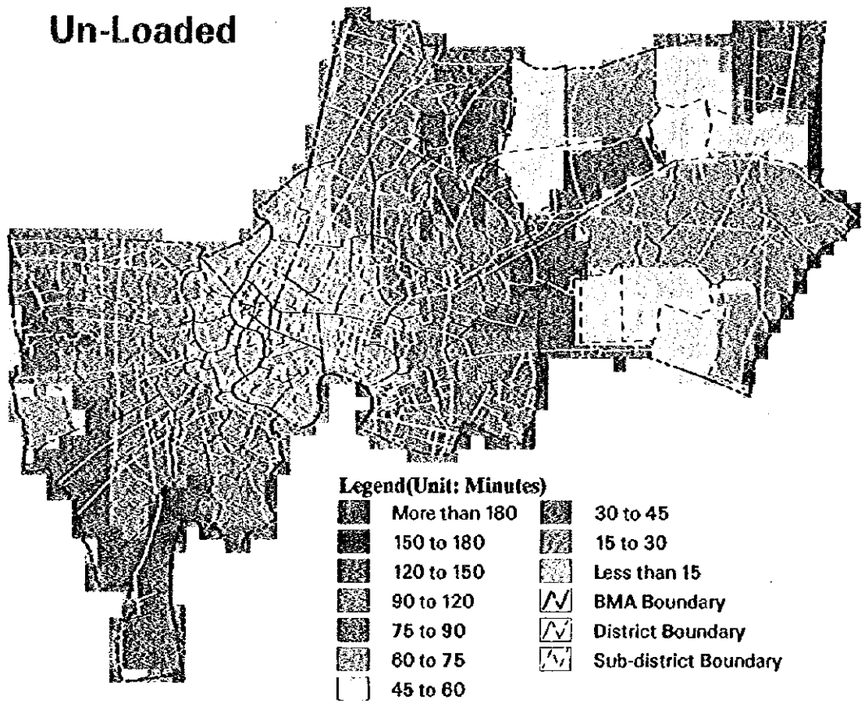
Fig. 3.18

Transport Accessibility

Un-Loaded



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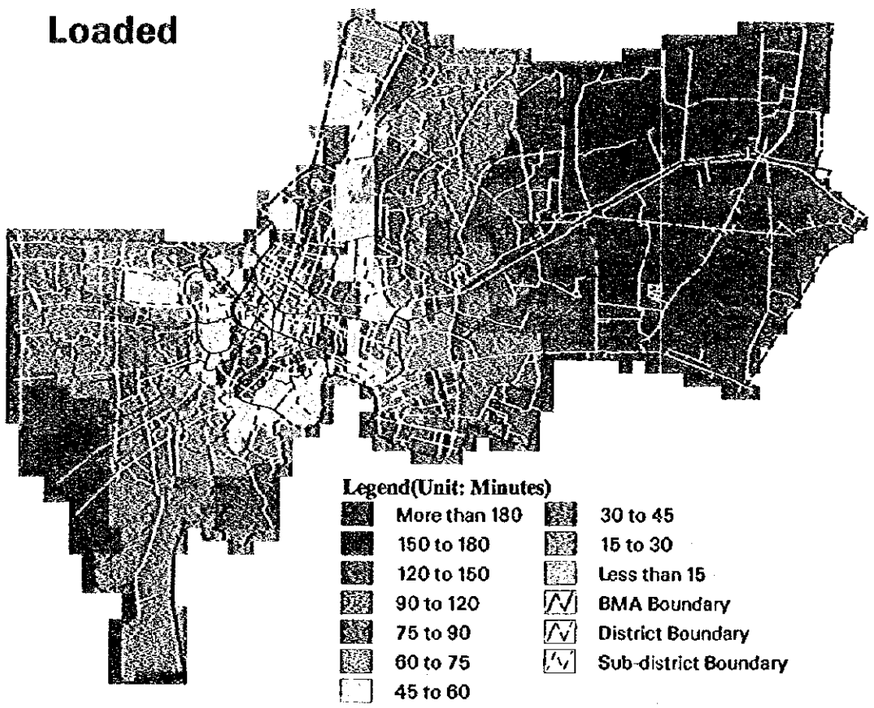
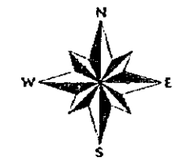


Legend(Unit: Minutes)

More than 180	30 to 45
150 to 180	15 to 30
120 to 150	Less than 15
90 to 120	BMA Boundary
75 to 90	District Boundary
60 to 75	Sub-district Boundary
45 to 60	



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(9) Level of Congestion

Road congestion levels were simulated with the present road network, which is approximately 1,700 km long in the BMA area, including though-passable "Soi" as well as major roads.

The simulation result indicated that approximately 29%, or 500 km of roads are facing serious traffic congestion in the morning peak hours. Those congested roads are distributed within the 10 km radius areas from the Bangkok central area. Thus, all commuters whose work places are located in the central area cannot escape the severe traffic congestion every day.

Table 3.6 Level of Congestion of BMA Road System in the Morning Peak Hour

Level of Congestion	Share
1. Saturated	13.2 %
2. Heavily Congested	15.7 %
3. Congested	9.4 %
4. Acceptable	12.6 %
5. Under Capacity	49.1 %
Total Simulated Road	1732 km

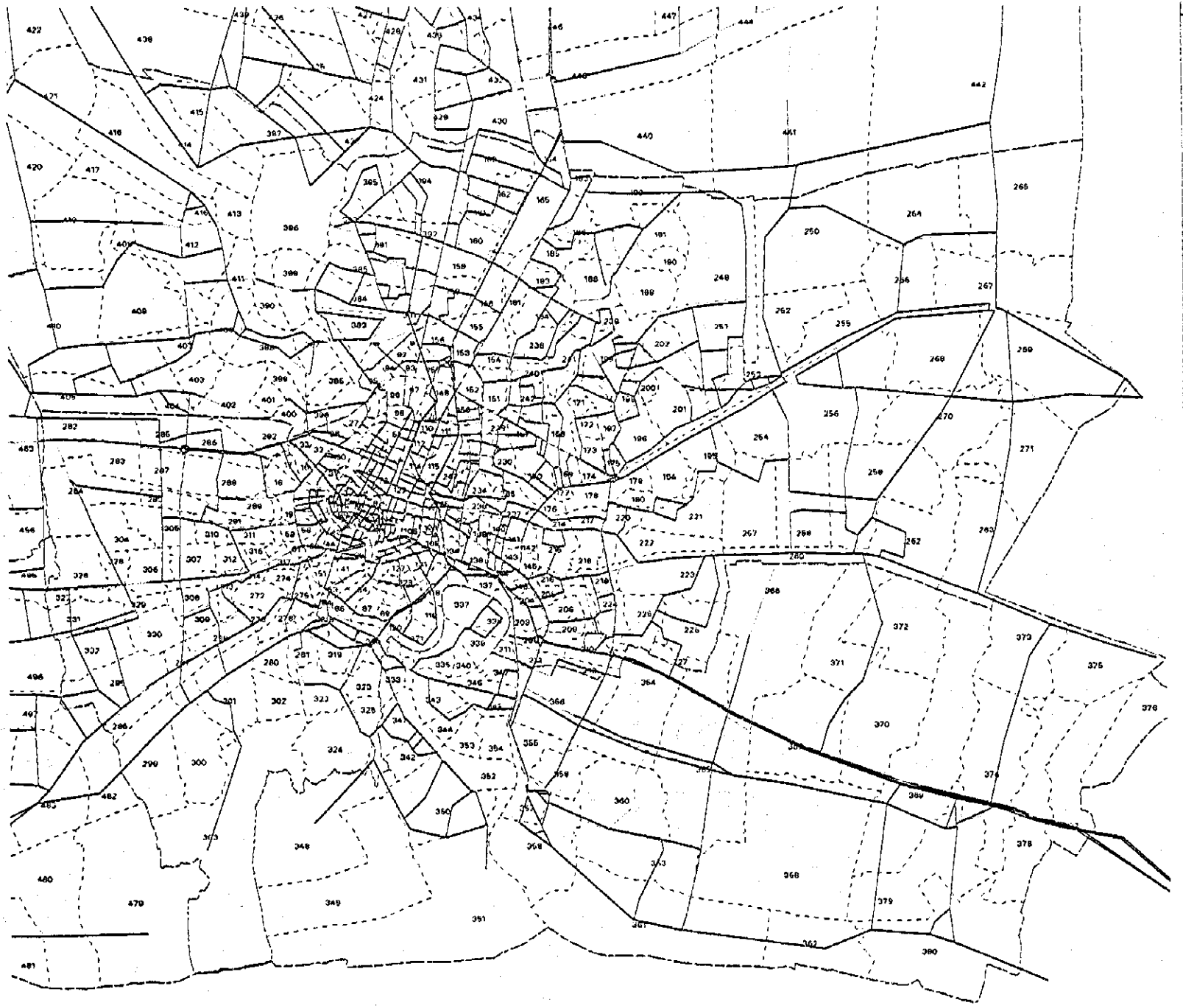
Source : BEIP simulation result (CASE 1)

(10) Major Transport Corridor

Certain trip characteristics of 5 major transport corridors which form a radial pattern of the Bangkok Metropolis, were examined, as shown in Fig. 3.20 and Table 3.7. The following are major findings from this analysis:

- Many of the longest car trips appear on Phahon Yothin Rd. running along the northern corridor and Lat Phrao Rd. which is used for in-flow trips from the eastern area. However, bus trips using the same roads have relatively short trip lengths.
- These two major roads are well-knows to be heavily congested roads. One of the reasons is the fact that many considerably long car trips are mixed with short trips. Therefore, provision of mass transportation systems in the northern and eastern corridors to absorb these long car trips may bring about an effective solution with regard to the present heavy traffic congestion.
- Looking at the trip length distribution of other corridors, most of the car trips fall within the range of 10-20 km.

Fig. 3.19



Level of Road Traffic Congestion (case1)

Legend

- Provincial Boundary
- Saturated
- Heavily Congested
- Congested
- Acceptable
- Under Capacity

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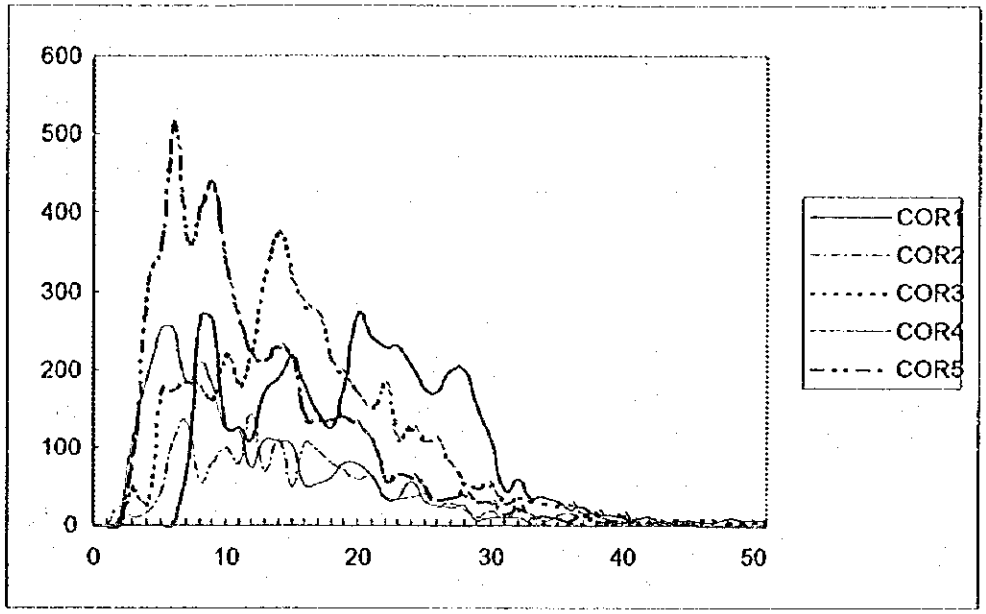


Fig. 3.20 Frequency of Vehicle Trips (PCU) by Distances

Table 3.7 PCU Trips crossing through the Major Corridor by Trip Length in Morning Peak Hour

	COR 1		COR 2		COR 3		COR 4		COR 5	
0-5 km	-	0.0%	47	1.5%	73	1.8%	309	7.9%	402	8.1%
5-10 km	597	18.6%	418	13.2%	867	21.0%	1,078	27.6%	2,084	41.9%
10-15km	720	22.5%	502	15.8%	1,317	32.0%	534	13.7%	1,244	25.0%
15-20km	85	2.7%	841	26.5%	397	9.6%	1,258	32.2%	348	7.0%
20-25km	1,172	36.6%	229	7.2%	727	17.6%	266	6.8%	428	8.6%
25-30km	135	4.2%	894	28.2%	123	3.0%	400	10.2%	110	2.2%
30-35km	291	9.1%	66	2.1%	179	4.3%	34	0.9%	95	1.9%
35-	205	6.4%	174	5.5%	438	10.6%	30	0.8%	267	5.4%
TOTAL	3,205	100.0%	3,171	100.0%	4,121	100.0%	3,909	100.0%	4,978	100.0%
AVG TRIP LENGTH	19.6km		15.4km		16.2km		11.5km		11.9km	

NOTE: NUMBER OF TRIPS ARE SIMULATED INBOUND (ONE-WAY) VEHICULAR TRIPS IN PCU.

COR1 : PHAHON YOTHIN CORRIDOR NEAR RAM INTHRA RD.

COR2 : LAT PHRAO CORRIDOR

COR3 : RAMA IV CORRIDOR

COR4 : PINKLAO CORRIDOR (PHRA PIN KLAO BRIDGE)

COR5 : THONBURI CORRIDOR (CHAO TAKSIN BRIDGE)

(11)Hierarchical Road System

In order to function well, roads should be developed and/or improved with a hierarchical road network system.

At present, primary arterial roads (defined as "inter-city roads" in BEIP), in view of the existing truck control zone, have been recognized as the Middle Ring Road (MRR) formed by Ratchadaphisek Rd., Soi Asok, Rama III and Sanit Wong Rd. and some major radial roads connecting with the MRR. Inside the MRR, no primary arterial roads should exist. Fig. 3.21 shows the current road system as a hierarchy, which, however, differ from BEIP's understanding of the road system.

The areas served by the MRR have already been highly urbanized at present, thereby resulting in the worsening its primary arterial functions. The hierarchical system, therefore, should be reviewed in consideration of the urbanization process. A new primary arterial network should be formed with an alternative arterial ring road along the ETA Ring Road and the major radial roads connecting to it.

The secondary arterial system needs to be developed within the structural framework of the primary system. A higher road density, in terms of service intervals, is required particularly inside the new ring primary artery, say, 500-1,000 m, that is, almost the same level as that in the old city area. The secondary arterial roads should have urban functions that provide amenities and benefit the environment such as green and open spaces, symbolic monuments and comfortable pedestrian paths as well as inter-modal facilities among public transportation modes.

3.4 Urban Utility and Sanitary Services

(1) Water Supply

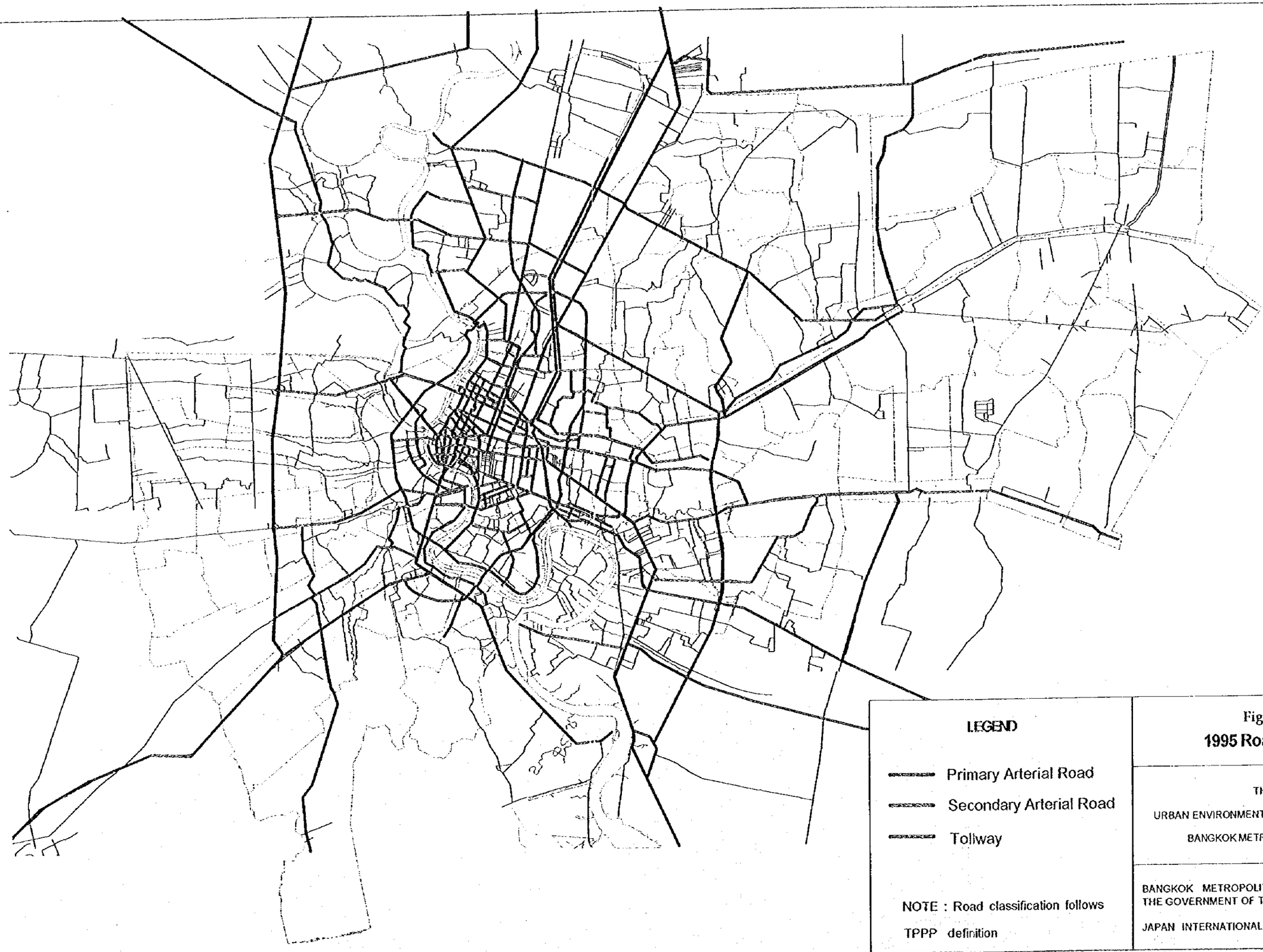
Most of the residents in Bangkok obtain water from the Chao Phraya River through the MWA water supply system and through small-scale groundwater supply systems in the suburban area. In the dry season, the river flow decreases to a minimum flow 100 cm which causes of a raw water intake problem due to the flow rate, and causes sea-water intrusion. The master plan of MWA formulated for 2017 plans to withdraw approximately 60 cm of raw water from the Chao Phraya River to utilize the river water to the maximum extent so as to keep the maintenance flow in the lower stream reaches.

Eighty (80) units of deep wells owned by MWA have a yielding capacity at 240,000 cm^3/day and the deep wells owned by the private sectors are estimated to yield more or less one million cubic meters per day. These deep wells cause the land subsidence problem in urban areas.

Raw water is well-treated within the drinking water quality standards. However, turbid water from taps and water contamination in negative pressure zones, low distribution pressure, water leakage, etc. are matters for concern with regard to improvement of the water distribution system in order to provide safe and sufficient water constantly to the entire service area.

(2) Drainage and Sewerage

The Si Phraya Waste Water Treatment Plant started operation at the end of 1995 with the inflow rate of 8,000 m^3/day approximately. The plant is planned to treat up to 30,000 m^3/day of waste water after completion of sewage collection and interceptor mains. In addition, the on-going six sewage projects plan to treat 972,000 m^3/day of waste water which is about one third of the sewage amount to be generated in 2011. These sewage projects tend to be delayed with regard to developing initial practical sewage treatment facilities for Bangkok. Meanwhile, waste water is running into the khlongs and the rivers every day which contribute to the water pollution problem.



LEGEND

Primary Arterial Road

Secondary Arterial Road

Tollway

NOTE : Road classification follows TPPP definition

Fig. 3.21

1995 Road Network

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The master plan prepared by PCD in 1993 formulates the projects of 24 sewage zones for Bangkok that can treat up to 2.7 million m^3/day of waste water or appropriately 80 % of the sewage amount to be generated in 2011. Urban growth in the recent years and the future will change the amount and sources of waste water generation which will necessitate a review of the sewage master plan in coordination with the General Plan of Bangkok.

(3) Solid Waste

Solid waste collected from residential areas and business activities amounted to approximately 6,500 tons daily in 1995. Currently, the compost plant in On Nut treats 1,000 tons of solid waste, producing 300 tons of compost, and rejecting approximately 700 tons every day. However, most of the solid waste is disposed by sanitary landfill sites located in Nakhon Phatom and in Lat Krabang under contracts with the private waste management companies.

The existing landfill sites are filled with a large amount of garbage and there is no space available to receive more solid waste any more. BMA must acquire own landfill sites urgently. As basic rule of the society, possible sources of pollution such as waste water and/or solid waste must be treated at the place of generation.

Reduction of the solid waste volume for disposal can prolong the life of landfill sites. Incineration of solid waste is the most effective method for realizing reduction of solid waste volume as the waste is reduced to the minimum, and the ashes can be effectively disposed of. Existing incineration plant projects should be completed as soon as possible to save Bangkok from environmental deterioration.

The per capita solid waste generation rate per day increased annually from 657 grams in 1990 to 805 grams in 1995, that is, 4 to 5 % annually. At this rate, per capita solid waste generation will reach 1.5 kg per capita per day in 2011. The solid waste generation rate can be reduced through recycling and with the participation of communities, enterprises, and the authorities concerned.

3.5 Residential Environment

(1) Green Areas and Open Spaces

According to the existing land use analysis, parks occupy only 10 Km^2 or 0.6 % of the total area. This is equivalent to 1.25 m^2 of available park space for each person. This figure is much lower compared to other large cities in the world (for example, Tokyo has 4 m^2/person of parks). In terms of the spatial distribution, the central area has relatively large area of parks and open spaces, while other areas have smaller areas of parks and open spaces. As for public parks, Bangkok has only 26 major public parks.

With regard to open spaces, approximately 30 % of the total area of Bangkok is built-up. The built-up areas spread along major transport corridors, resulting little open spaces remaining in the central area. Suburban areas have wider open spaces, nevertheless, residential and industrial development is rapidly occurring.

(2) Accessibility to Public Community Services

Table 3.8 shows some urban community facilities such as a library and youth center. With regard to the library, it is implied that recent urbanization is not concomitant with adequate consideration for urban amenities. Suburban areas still have large areas with less accessibility to hospitals.

Table 3.8 Availability of Selected Community Services by District

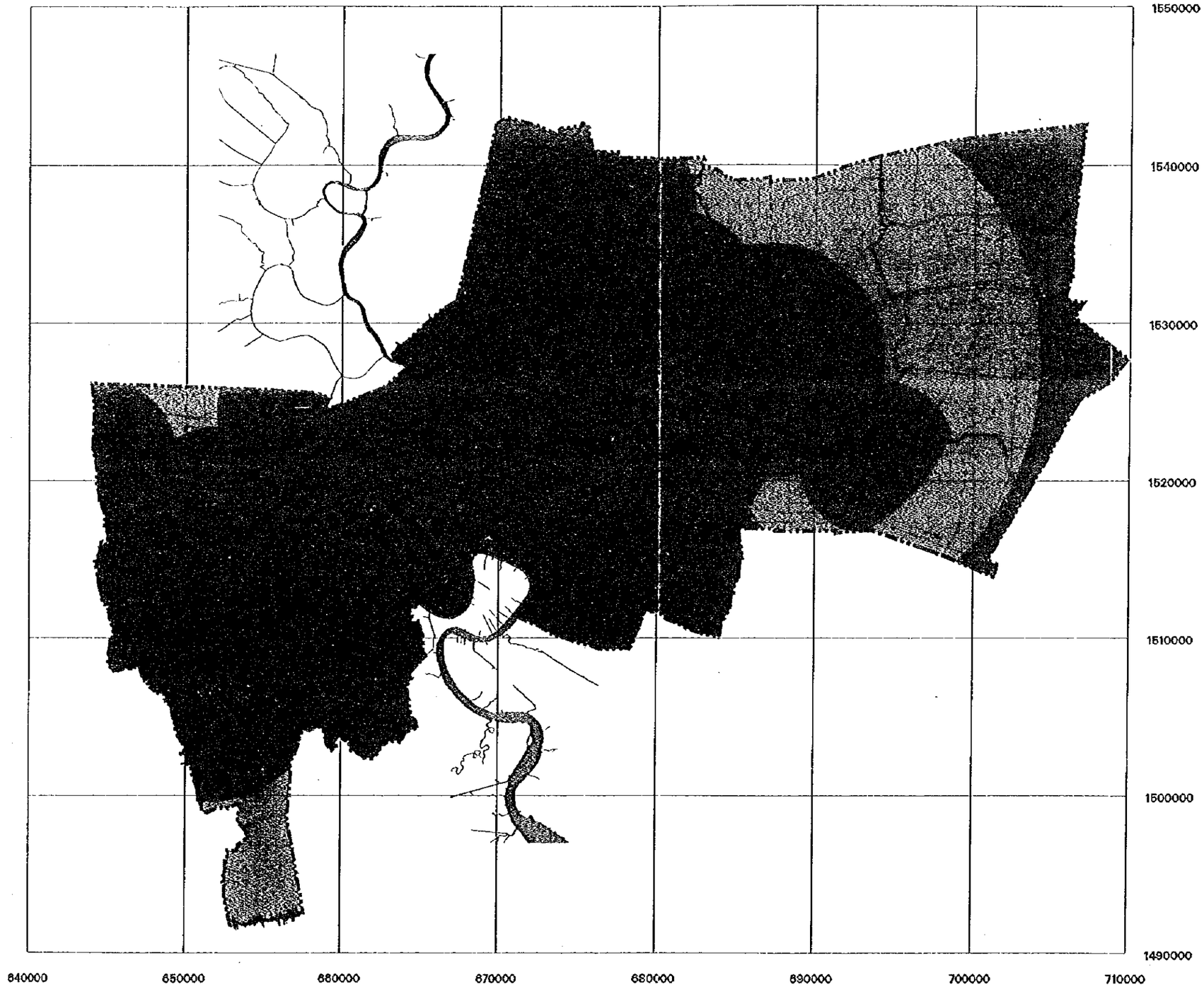
	Libraries	Parks (sq.m)				Youth	Park per Person
		Public Park	Open Space	Play Ground	Total	Center	(sq.m/person)
Pra Nakhon	1	36,800	158,382	240	195,422	2	2.13
Khlong Toei					0		0.00
Klong San	1		892		892		0.01
Chatuchak		304,000	94,916		398,916		2.17
Chom Thong	1				0		0.00
Don Muang					0		0.00
Dusit			49,860	80	49,940	1	0.28
Taling Chan	1			420	420	1	0.00
Thon Buri			77,720	280	78,000	1	0.34
Bangkok Noi			51,300	160	51,460	2	0.29
Bangkok Yai	1		100	40	140	1	0.00
Bang Kapi		560,000			560,000		2.41
Bang Khun Thian					0	1	0.00
Bang Khen	1			320	320	1	0.00
Bang Kho Laem					0		0.00
Bang Sue			1,200		1,200	1	0.01
Bang Phlat					0		0.00
Bang Rak			1,056	40	1,096	1	0.01
Bung Kum					0		0.00
Pathum Wan	2	576,000	3,100	3,600	582,700	3	4.72
Prawet	1				0	1	0.00
Pom Prap			4,100	120	4,220	1	0.05
Phaya Thai	1		680		680		0.00
Phra Khanong		800,000	1,300	940	802,240	3	3.99
Phasi Charoen	1				0		0.00
Min Buri					0	1	0.00
Yan Nawa			3,612	300	3,912	1	0.04
Ratchthewi			25,571		25,571		0.23
Rat Buruna		101,280			101,280	1	0.61
Lat Krabang		80,000			80,000	1	1.04
Lat Phrao	1				0		0.00
Sam Phanthawong			1,950		1,950		0.04
Sathon					0		0.00
Nong Khaem					0	1	0.00
Nong Chok		56,800			56,800		0.89
Huai Khwang			34,597	560	35,157	1	0.14
Din Daeng					0		
Suan Luang					0		
Bangkok Total	12	2,514,880	510,335	7,100	3,032,315	26	0.55

Source: Statistical Profile of BMA, 1993

(3) Accessibility to Shopping Centers

Convenience is a large factor for land potential as well as accessibility and natural conditions. Proximity to the commercial facilities such as department stores and shopping centers is a typical indicator in terms of convenience. Fig. 3.22 shows accessibility to commercial areas. The areas with suitable accessibility are spread along major arterial roads, but newly developed suburban areas such as Bang Kapi, Bung Kum and Prawet districts does not have sufficient accessibility to commercial areas.

Accessibility to Commercial Areas



Legend

- 1 ~ 2
- 3 ~ 4
- 5 ~ 6
- 7 ~ 8
- 9 ~ 10
- Main Road
- BMA Boundary
- District Boundary
- Subdistrict Boundary
- Chaopraya River

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KILOMETERS

UTM Zone 47

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3.6 An Overall Assessment (Comprehensive Environmental Problem Maps)

(1) Methodology for the Environmental Assessment

The Study Team has started to collect existing data regarding the urban environment, focusing especially on urban development, urban transport, air pollution, water pollution and solid waste. To supplement the data collected, the Study Team conducted field surveys such as the FAR Survey, the Home Interview Survey, the Special Generation Survey, the Water Quality Test and the Ambient Air Quality Test. Simulations are carried out to calibrate existing conditions for urbanized areas, traffic and air pollution. These data are then integrated into GIS system to identify environmental problem areas by overlaying several analyzed and simulated data. The flow chart of the analyses is shown in Fig. 3.23.

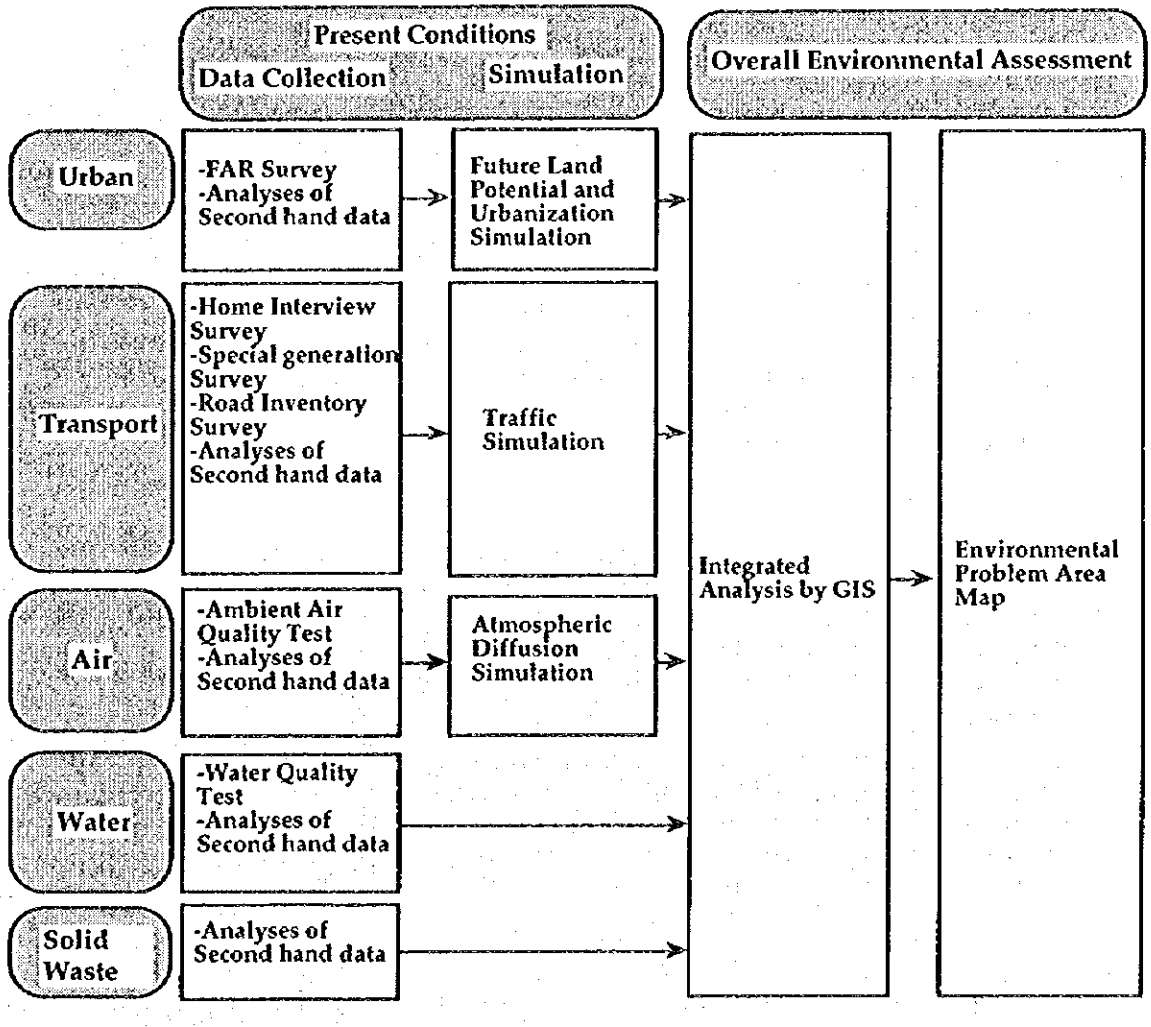


Fig. 3.23 Overall Flow of Urban Environmental Assessment

(2) Identification of Urban Environmental Problems

1) Problems on Natural Condition

Flood

Flooding is the most serious problem caused by natural conditions in Bangkok. It heavily depends on natural vulnerability. Once Bangkok suffers from floods, it is difficult to drain water away due to the low alluvium flat plane of the Chao Phraya River Delta. The low land in Phra Khanong, Lat Phrao, Suan Luang, Bang Kapi, Khlong Toei, Huai Khwang, Jomtong and Prawet districts as well as the areas along the Chao Phraya River and outside King's dike are identified as serious inundation problem areas.

Land Subsidence

Rapid urbanization, modernization and industrialization are all demanding more water, however the adequate water supply service can not keep up with the demand. This eventually has increased the groundwater usage.

The land subsidence would accelerate flood problems more seriously in suburban areas. Bangkok Yai, Khlong San, Bangkok Noi, Phasi Charoen, Huai Khwang and Nong Khaem districts are anticipated to face severe land subsidence at over 100 cm by 2017.

2) Problems of Urban Function

High densely Populated Area

A Number of sub-districts in central areas such as Bang Rak, Samphanthawon, Pom Prap Sattruphai, Khlong San and Thon Buri districts have extremely high population densities, which accounts for around 800 to 950 person/ha. Mixed land use and very small living spaces with a high population density eventually deteriorate the living environment, resulting in people moving from these areas and a consequent decrease in population currently decreasing the population.

Traffic Congestion

Although there is a relatively higher road density in the central area than in the suburban areas, more traffic demand is created (generation and attraction), so that the demand-supply gap has apparently become large, resulting in heavy traffic congestion. Bang Rak, Pathumwan, Pom Prap Sattaruphai districts are the typical cases. Some district surrounding the central area such as the Khlong Toei and Khlong San districts have suffered from the problem.

In suburban areas such as Yan Nawa, Din Daeng, Don Muang, Bang Kapi, Prawet, Taling Chan and Bang Khun Thian, there is relatively low road density with a higher traffic demand due to the population increase. This implies that demand-side measures are necessary for the central area, while supply-side measures are necessary for the urbanized suburban districts.

Urban Sprawl

In response to high land development pressure in the outskirts of Bangkok, disorderly urbanization or urban sprawl is rapidly taking place. It is mainly observed in the Bang Khen, Bang Kapi, Suan Luang, Minburi, Taling Chan, Rat Burana, Phasi Charoen and Bang Khun Thian districts. This generates low-standard living environmental areas without sufficient infrastructure and will consequently necessitate excessive public investment afterwards. To avoid such urban sprawl, it is necessary to control land development projects in these areas.

Declining Traditional Stocks and Green Areas in the Inner City

Major landmarks representing the traditional Thai urban landscape such as the khlong network, wooden two story shop houses and Thai traditional architecture, have been replaced by roads and modern buildings. Only the Ratanakosin area maintains the invaluable traditional urban landscape. Green areas and open spaces are also disappearing and only 10 Km^2 or 0.6 % of the total area remains. This is equivalent to 1.25 m^2 per person. In the built-up areas, there are few large green areas. Green areas are scattered and can be found mostly on private property.

3) Environmental Loads caused by Urban Activities

Air Pollution

Most of the built-up areas suffer from air pollution. Among the pollutants, the most critical situation is the concentrations of TSP, followed by NO_2. Concentrations of CO and SO_2 are also problematic but are relatively less serious than TSP and NO_2. Dust from construction sites is considered to be one of the major sources of TSP together with vehicle emission gas.

Water Pollution

Due to the delay of development of sewerage systems in Bangkok, waste water is running into the khlongs and rivers, resulting in water pollution problems. Aquatic life along the khlongs is threatened in the central part of the city. Khlong contaminated water areas extend to a considerably wider area, from the Khlong Lad Phrao to the Khlong Phra Khanong line to the west on the Bangkok side and from Khlong Bangkok Yai to Chom Thong and Rat Burana Districts line to the east on the Thon Buri side.

However, such water contamination is slightly being improved in some khlongs in recent years because of efforts on inducing of introducing dilution water.

Solid Waste

At the rate of the current increase, per capita solid waste generation rate will reach at 1.5 kg per capita per day in 2011. This will create more serious problems for solid waste management.

As for the solid waste collection, the area with insufficient garbage collection capacity will increase in the suburban areas. As for disposal, it is an urgent issue to make available long-life final disposal sites within the BMA jurisdiction. Since environmentally-sound solid waste disposal is strongly required, BMA must make much effort to reduce the waste volume by encouraging recycling and by introducing more intermediate treatment facilities.

(3) Distribution Pattern of Urban Environmental Problems/ Difficulties

Urban environmental problems are spread over Bangkok. Air pollution, water pollution, traffic congestion and high-population density can be found in the central area. On the other hand, in the suburban areas, flooding, land subsidence, water pollution, the overload of solid waste collection and urban sprawl are serious urban environmental problems. Table 3. 9 and Fig. 3. 24 show the conceptual distribution of urban environmental problems.

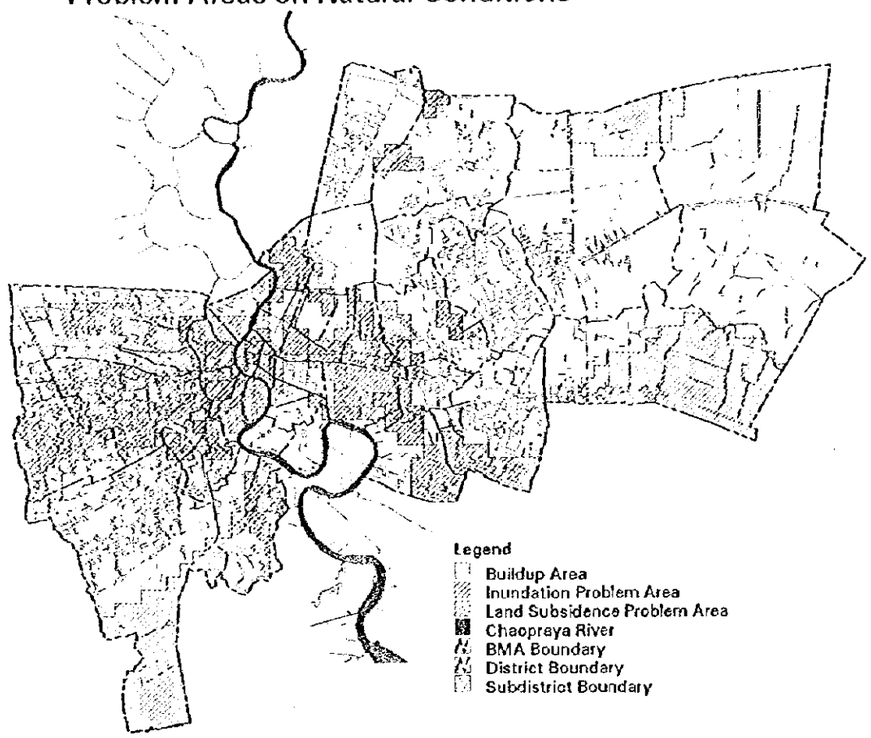
Table 3.9 Distribution of Urban Environmental Problems

	Input (Urban Anabolism)		Urban Function			Output (Urban Catabolism)		
	Natural Conditions	Water Supply	Current Urban Activities	Housing and Quality of Living	Traffic and Transport	Air Pollution	Water Pollution	Garbage
Central Area	Chao Praya Riverside at Thonburi side is dangerous in terms of inundation.	Water supply covers whole area.	Land integration for commercial and business buildings Mixed with population increased and decreased areas	High densely inhabited.	Although road density is relatively high, roads are very congested with much traffic demand.	TSP and NOx are not satisfied by Thai environmental standard in most area.	Less problem at this moment.	Less problem
Surrounding Area of Central Area	Suburban residential area is dangerous in terms of inundation in case heavy rain.	Water supply covers whole area.	Land integration for both commercial and residential buildings. Mixed with population increased and decreased areas	High densely inhabited. Parks and greens are not adequately provided.	Low roads density causes traffic congestion and unsatisfied accessibility of large vehicle like emergency car.	TSP and NOx are not satisfied by Thai environmental standard in most area.	Khlong water is polluted without sewerage system.	Less problem
Urbanized Suburban Residential Area	Suburban residential area is dangerous in terms of inundation in case heavy rain.	Water supply covers almost whole area.	Expansion of residential areas Population is increased.	Parks and greens are not adequately provided.	Certain areas receive more time loss from traffic congestion. There are several low road density areas.	Less Problem at this moment	Khlong water is polluted without sewerage. It would be getting worse with rapid population growth.	Since population is rapidly increased, collection capacity is not meet with garbage generation.
Suburban Area to be Urbanized	Outside areas of King's dike are not protected from flood.	Extension plan of water supply has prepared, accordingly, timing of project is a key issue. Use of well water is a one factor of ground subsidence.	Land subdivision development Population is increased.	Urban facilities such as commercial facilities, school, hospital are not adequately provided.	Less problem at this moment.	Less Problem at this moment	Khlong water will be deteriorated since population is now increasing without sewerage.	Less problem

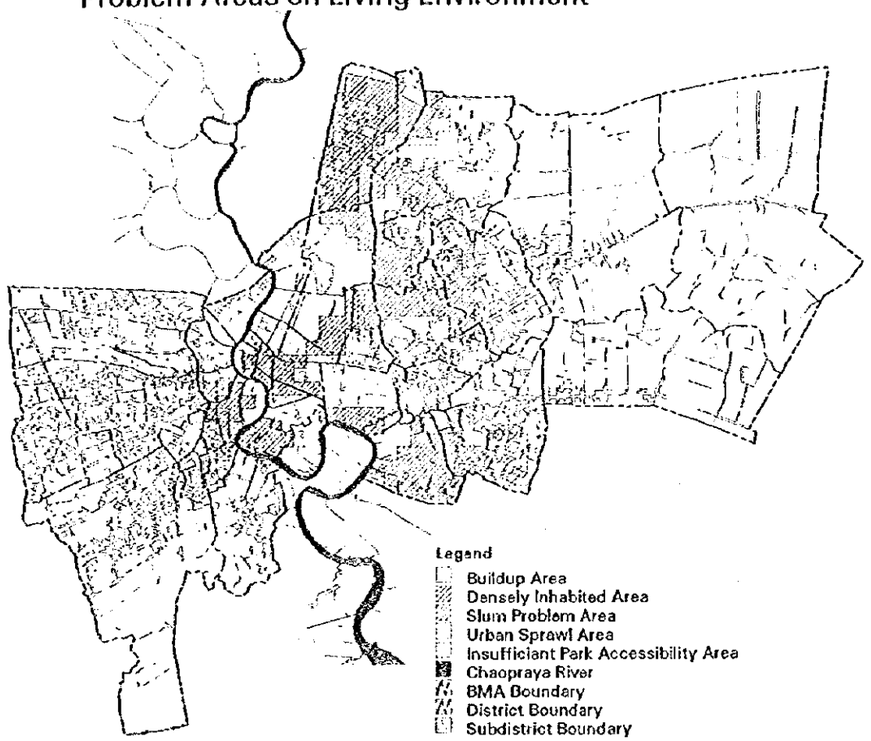
Fig. 3. 24

Urban Environmental Problems Map

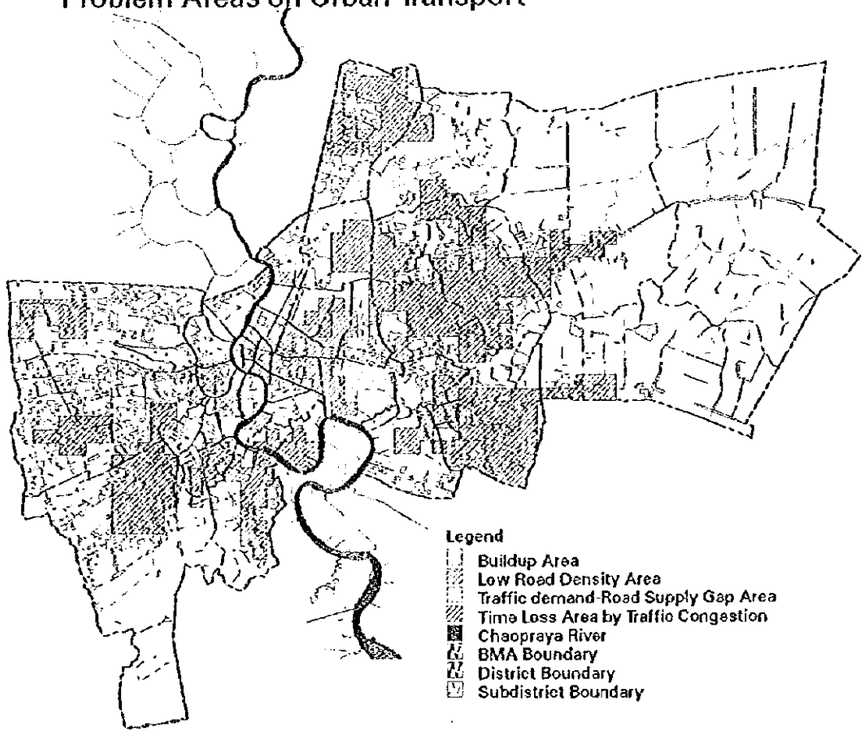
Problem Areas on Natural Conditions



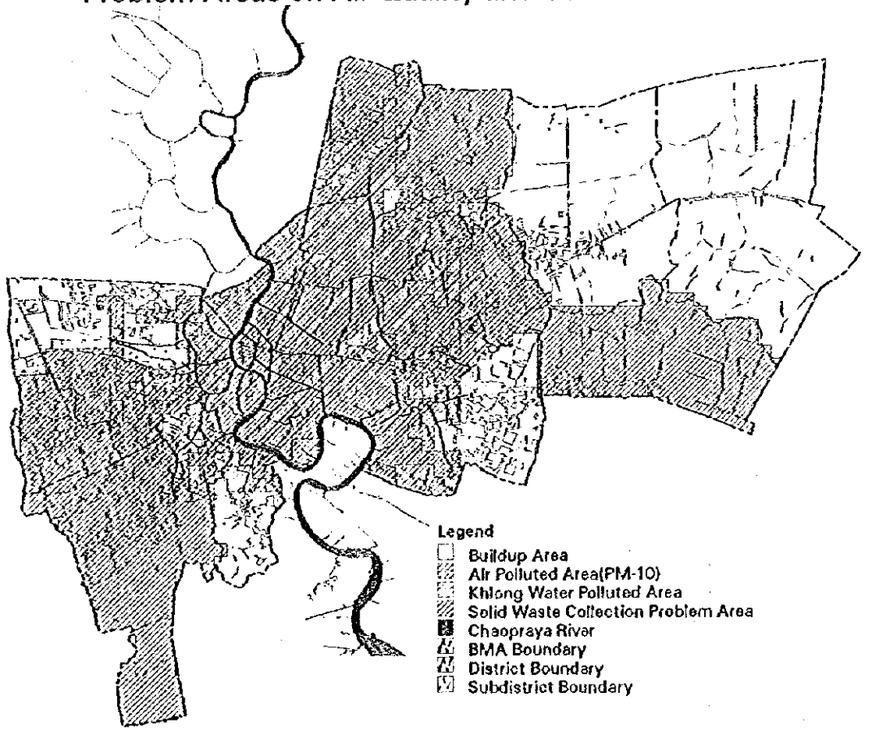
Problem Areas on Living Environment



Problem Areas on Urban Transport



Problem Areas on Air Quality and Solid Waste



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