CHAPTER 6: SIMULATION ANALYSES OF AIR POLLUTION BY MOBILE SOURCE

6.1 Objective of the Analysis

In order to review the present condition and evaluate the effects of policies in the future, simulation analysis of air pollutants is introduced. Simulated policy options are related only to vehicles because air pollution is mainly caused by vehicles.

The targets of "BEIP Simulation Model for Air Pollution" are as follows:

- Simulated air pollutants are SO2, NOX, NO2, PM-10 and CO;
- Pollutant sources are motor vehicles, thermal power plants, and household; and
- Target area of concentration calculation is BMA.

6.2 Methodology

First, emissions from vehicle and power plants, which are supposed to be major sources of pollution, and the emissions from households are estimated. Their ground level concentrations are computed by the "BEIP Simulation Model for Air Pollution". Simulated cases are listed in Section 6.4 and the BEIP Simulation Model for Air Pollution is described in Section 6.5.

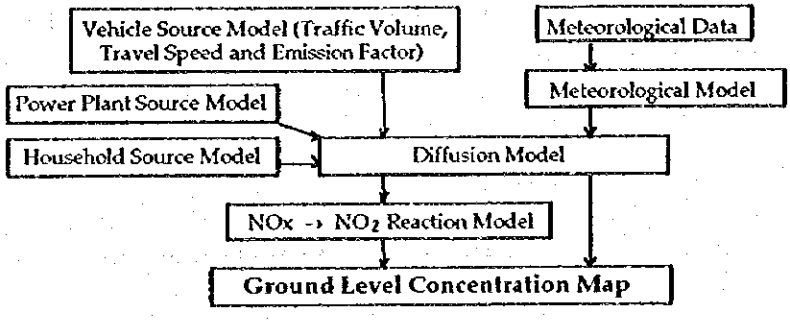

Fig. 6.1 Flow Chart of Simulation Model

6.3 Policy Options for Air Pollution Mitigation

Air pollution from vehicles will be mitigated by the following three conditions:

- Reduction of pollutant emission per vehicle;

- Change of traffic volume and travel speed by improvement of transport network; and
- Change of transportation demand reflecting urban structure development.

(1) Emission per Vehicle

1) Current Vehicle Emission (C)[1]

The emission factors of the "Air Emission Database of Vehicles and Industry in Bangkok Metropolitan Region 1992: PCD MOSTE" were applied for the current condition

2) Future Vehicle Emission under Planned Policies (P)

The emission factors were estimated to simulate the following two policies;

- Almost all the vehicles would meet the New Vehicle Regulation because all new vehicles will have to meet the strong regulations after January 1999, as in European countries (PCD, 1996); and
- Sulfur content of high speed diesel oil is considered to be 0.05% in 2011.

3) Replacement by Low-Emission Bus (A)

To consider further improvement of emission, another case is simulated that average of emission factor of bus is decreased to be half. It may be actualized by some policies, e.g., some of the bus routes are replaced by tram or trolley bus system, and the other routes are operated by CNG bus.

(2) Transport Network

Following 3 cases have already been described in Chapter 5.

- Current Transport Network (C)
- Road Construction of the 8th National Plan (P)
- Implementation of the Mass Transit Master Plan (P)

The other simulated case is Extreme Modal Shift (A). The aim of this case is to obtain a numerical effect of the modal shift in order to consider further control of air pollution. The simulated setting is so tentative that all small sized vehicles except taxies and samlors shifted to buses.

(3) Transport Demand

1) Transport Demand in 2011 (Free Case) (P)

The transportation demand will be increased by the growth of the economy and population, and urbanization. This case simulated transport demand change under conditions of free urbanization.

2) Transport Demand in 2011 under Sub Center Development (B)

The effect of transportation demand change under Sub Center Development, proposed by this BEIP Study Team, was evaluated in this case.

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[1] Conditions of the current situation are marked as (C), conditions of future probable situations as (P), BEIP recommendations as (B), and other additional future conditions as (A).

6.4 Combination of Cases

Nine (9) cases of combination were simulated as shown in Table 6.1. The purpose of each case is:

- Case 1 : to simulate current air pollution;
- Case 2 - Case 4: to evaluate future probable policies;
- Case 5 - Case 7: to recognize the effect of the transport demand difference; and
- Case 7 - Case 9: to understand the importance of additional future policies.

Table 6.1 Simulated Cases

	Case								
	1	2	3	4	5	6	7	8	9
*	*C)	P)	P)	P)	P)	P)	B)	A)	A)
C) Current Vehicle Emission	O	-	O	O	-	-	-	-	-
P) Future Vehicle Emission	-	O	-	-	O	O	O	O	O
A) Low-Emission Bus	-	-	-	-	-	-	-	-	O
C) Current Road Network	O	O	-	-	-	-	-	-	-
P) Road Construction of the 8th National Plan	-	-	O	O	O	O	O	O	O
P) Implementation of the MRT	-	-	-	O	O	O	O	O	O
A) Extreme Modal Shift	-	-	-	-	-	-	-	O	-
C) Current Transport Demand	O	O	O	O	O	-	-	-	-
P) Transport Demand in 2011 (Free Case)	-	-	-	-	-	O	-	-	-
B) In 2011 under Sub Center Development Case	-	-	-	-	-	-	O	O	O

Note: see footnote in the previous page

6.5 Applied Simulation Model

(1) Emission Model

Emissions from vehicles were estimated by using emission factors, traffic volume and travel speed of each traffic links. The emission factors applied for estimation are quoted from the "Air Emission Database of Vehicles and Industry in Bangkok Metropolitan Region 1992: PCD MOSTE." Emission factors under future conditions were estimated by the BEIP Study Team. The road network, travel speed and traffic volume data by 9 vehicle types were provided from the outcomes of the analysis of the traffic planning sector of the BEIP Study Team.

The emission data of the power plants were mainly obtained from the "Air Emission Database of Vehicles and Industry in Bangkok Metropolitan Region 1992: PCD MOSTE."

Emissions from households were estimated by the amount of fuel consumption and the emission factor. Both are quoted from the "Air Emission Database of Vehicles and Industry in Bangkok Metropolitan Region 1992: PCD MOSTE." The emission distribution was based on population distribution data estimated by this BEIP Study Team.

(2) The BEIP Simulation Model for Air Pollution

The BEIP Simulation Model for Air Pollution was a simulation model modified to emulate the situation of Bangkok, as the BEIP Study Team developed it by checking the simulation results with the actual ambient monitoring results.

The simulation procedure is shown in Fig. 6.2.

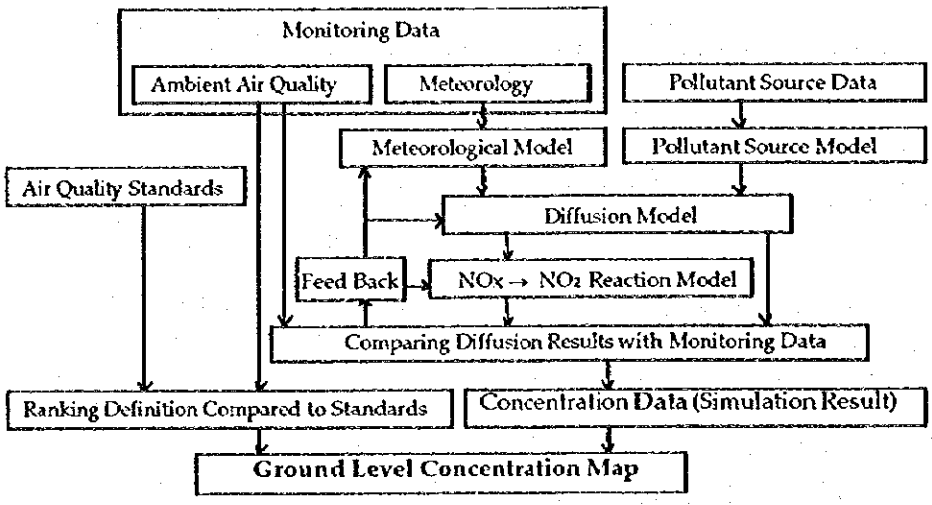


Fig. 6.2 Flow Chart of Diffusion Simulation

The outline of the model is as follows:

- Meteorological data observed at ONEB Station in 1988 by JICA;
- CONCAWE Equation (CONCAWE, 1966) and Briggs Equation (Briggs, 1969) for the height of the plume rise;
- Gaussian Plume Equation and Gaussian Puff Equation for the dispersion model; and
- Monitoring results of CO were used for model improvement.

The Scatter Diagram of estimated and actual CO concentration (annual) is shown in Fig. 6.3. The model is considered to have sufficient reproducibility as the gradient of regression line is near to 1.0 and the coefficient of correlation is more than 0.9.

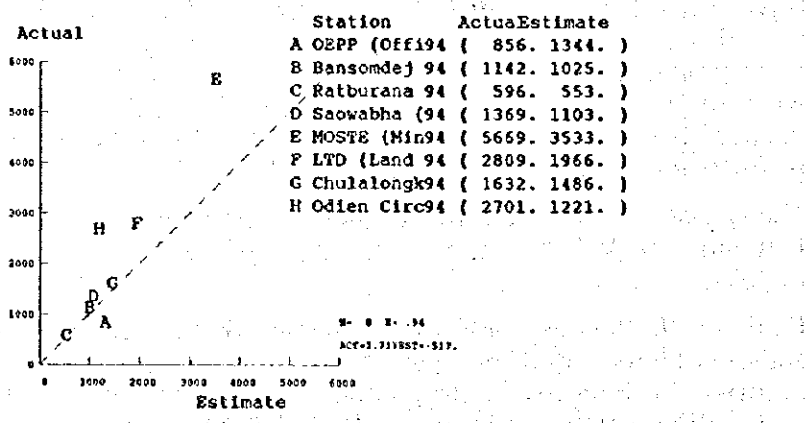


Fig. 6.3 Scatter Diagram Comparing the Simulation Result (Estimate) and the Monitoring Result in 1994 (Actual) (CO, ppb)

To compare the concentration of grid cells with standards, Table 6.2 was prepared by statistical analysis of existing ambient monitoring data.

Table 6.2 Ranking of the Annual Arithmetic Average of Air Pollutant Concentration, compared to the Ambient Air Standards

	PM-10 ($\mu g/m^3$)	CO (ppb)	SO_2 (ppb)	NO_2 (ppb)
Much Lower than the Standard	≤ 20	≤ 722	≤ 9	≤ 9
Lower than the Standard	≤ 40	≤ 1445	≤ 19	≤ 17
Possibly Lower than the Standard	≤ 52	≤ 2131	≤ 24	≤ 21
Possibly Higher than the Standard	≤ 88	≤ 4748	≤ 36	≤ 30
Higher than the Standard	≤ 177	≤ 9496	≤ 72	≤ 60
Extremely Higher than the Standard	177<	9496<	72<	60<

Source: BEIP Study Team

6.6 Interpretation of the Result of the Model Simulation

Pollutant emissions of all cases are shown in Table 6.3.

Table 6.3 Emissions from Vehicles and Area of Each Ranking by Case

Case Settings:

	Case:	Case 1 (C)	Case 2 (P)	Case 3 (P)	Case 4 (P)	Case 5 (P)	Case 6 (P)	Case 7 (B)	Case 8 (A)	Case 9 (A)
(C)	Current Vehicle Emission	O	-	O	O	-	-	-	-	-
(P)	Future Vehicle Emission	-	O	-	-	O	O	O	O	O
(A)	Low-Emission Bus	-	-	-	-	-	-	-	-	O
(C)	Current Road Network	O	O	-	-	-	-	-	-	-
(P)	Road Construction of 8th National Plan	-	-	O	O	O	O	O	O	O
(P)	Implementation of the MRT	-	-	-	O	O	O	O	O	O
(A)	Extreme Modal Shift	-	-	-	-	-	-	-	O	-
(C)	Current Transport Demand	O	O	O	O	O	-	-	-	-
(P)	Transport Demand in 2011 (Free Case)	-	-	-	-	-	O	-	-	-
(B)	In 2011 under Sub Center Development Case	-	-	-	-	-	-	O	O	O

Emission from Vehicle (BMR , ton/y):

Case:	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
SPM	206,920	33,353	204,062	179,492	33,918	87,870	78,325	32,069	77,644
CO	934,101	233,741	870,281	705,268	172,370	718,508	607,239	497,118	592,454
SOx	29,696	4,031	27,182	24,101	3,514	8,918	8,034	5,767	7,307
NOx	192,396	75,123	155,684	138,844	53,961	153,462	137,412	133,703	110,750

Concentration (Annual Average): Area of Each Rank (km²):

Pollutant	Rank	Concentration	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
PM-10	1	<=20	395.50	1,413.75	415.00	466.25	1,373.50	777.75	853.50	1,334.50	855.50
(micro g/m³)	2	<=40	444.50	217.00	404.00	441.50	258.50	432.75	437.25	298.00	437.25
	3	<=52	145.00	41.50	163.75	168.25	46.50	158.50	144.00	52.25	144.50
	4	<=88	324.00	32.50	339.25	343.00	28.25	228.75	198.00	23.00	196.00
	5	<=177	263.00	3.25	291.25	237.75	1.25	104.75	72.25	0.25	71.75
	6	177<	136.00	0.00	94.75	51.25	0.00	5.50	3.00	0.00	3.00
CO	1	<=722	1,551.75	1,705.25	1,593.00	1,658.75	1,708.00	1,629.50	1,660.50	1,689.25	1,661.25
(ppb)	2	<=1445	134.50	2.75	102.25	48.25	0.00	69.75	44.75	17.25	44.00
	3	<=2131	17.50	0.00	6.00	1.00	0.00	7.50	2.25	1.50	2.25
	4	<=4748	4.25	0.00	1.75	0.00	0.00	1.25	0.50	0.00	0.50
	5	<=9496	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6	9496<	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SO_2	1	<=9	1,275.25	1,509.25	1,312.50	1,354.75	1,523.25	1,473.75	1,481.25	1,501.50	1,483.25
(ppb)	2	<=19	287.75	190.75	302.50	287.25	176.50	220.75	214.75	196.75	213.25
	3	<=24	93.25	8.00	77.75	60.25	8.25	13.50	12.00	9.75	11.50
	4	<=36	48.25	0.00	15.25	5.75	0.00	0.00	0.00	0.00	0.00
	5	<=72	3.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6	72<	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NO_2	1	<=9	485.50	1,148.50	656.75	786.50	1,499.00	715.75	829.25	832.00	905.00
(ppb)	2	<=17	455.50	347.00	508.75	532.75	207.75	492.50	499.50	510.25	502.50
	3	<=21	144.50	82.75	171.75	156.00	1.25	171.25	140.00	129.50	121.25
	4	<=30	241.25	102.50	218.00	161.25	0.00	194.50	165.00	162.25	136.00
	5	<=60	283.75	27.25	152.25	71.50	0.00	133.50	74.25	74.00	43.25
	6	60<	97.50	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.00

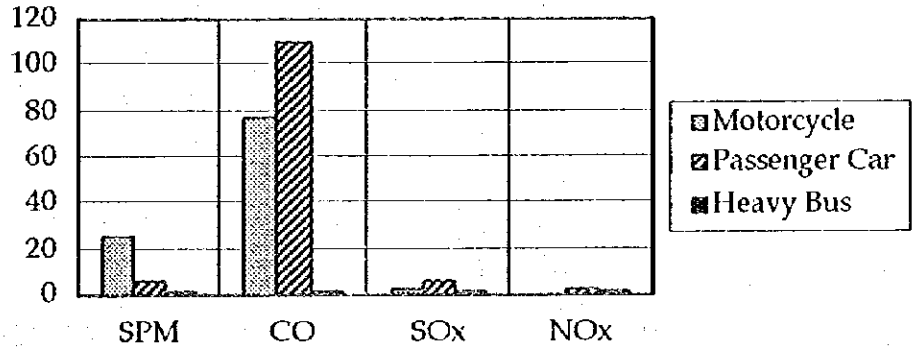
Source: JICA Study Team

Note:
Rank 1: Much Lower than the Standard
Rank 2: Lower than the Standard
Rank 3: Possibly Lower than the Standard
Rank 4: Possibly Higher than the Standard
Rank 5: Higher than the Standard
Rank 6: Extremely Higher than the Standard

(1) Simulation Results of Current Air Pollution (C) (Case 1)

1) Emission per Distance per Passenger

Emission per Distance per Passenger (hereinafter, Unit Pollutant Emission, g/km/person) was computed by the BEIP Study Team, shown Fig. 6.4. Buses show the lowest emissions of SOx, CO and SPM and the second lowest for NOx after motorcycles. The low emissions result for buses reflects their occupancy rate.



Source: BEIP Study Team

Fig. 6.4 Ratio of Unit Pollutant Emission (bus emission per passenger = 1.0)

2) Concentration Distribution of Air Pollutants

The concentration distribution of air pollutants is shown in Fig. 6.5.

The "Higher than the Standard" area of PM-10 covers the BMA widely, thus not contradicting the monitoring results that indicate that the majority of monitoring stations exceed the standard.

There is no area where the CO concentration is "Higher than the Standard" or "Extremely Higher than the Standard". The "Possibly Higher than the Standard" area is limited along some major roads. 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.

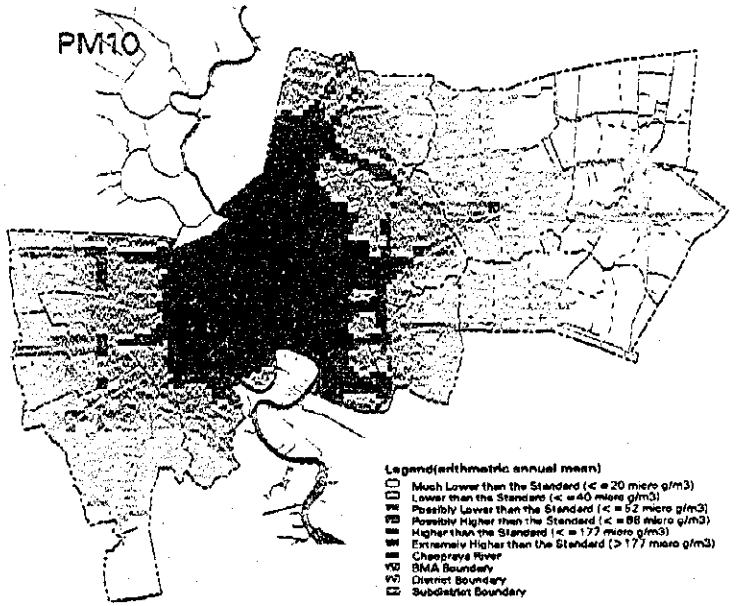
The "Higher than the Standard" area of SO_2 is limited to some major roads. The influence of power plants is an important factor in SO_2 air pollution. Since all the grid cells are "Possibly Lower than the Standard" or "Lower than the Standard", only air pollutants from motor vehicles are simulated.

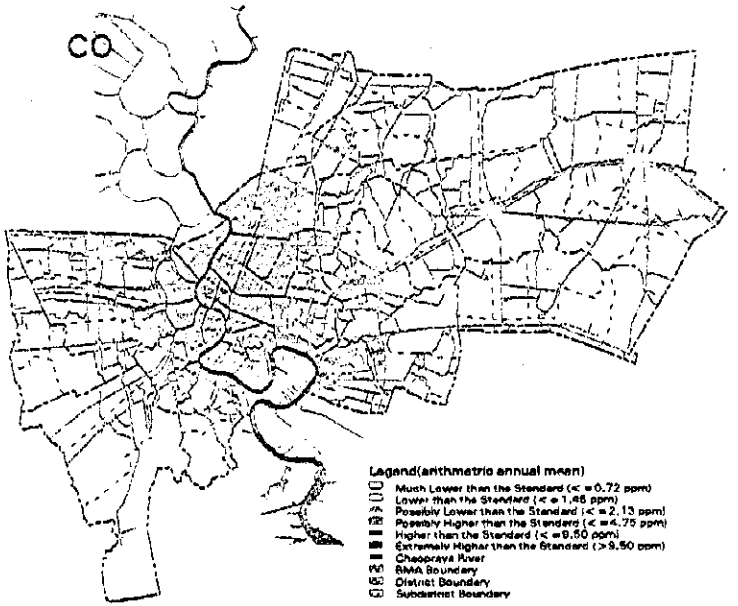
"Higher than the Standard" covers a wide area in the NO_2 map.

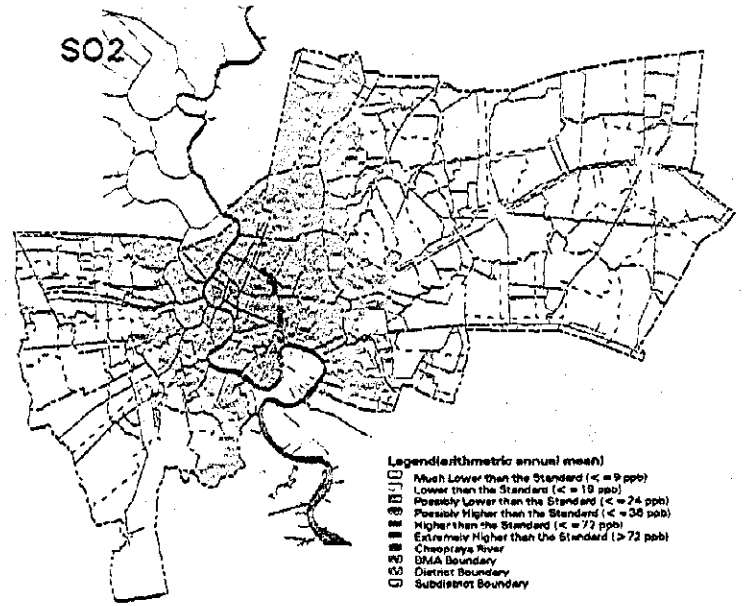
3) Top 20 Grid Cells of High Concentration:

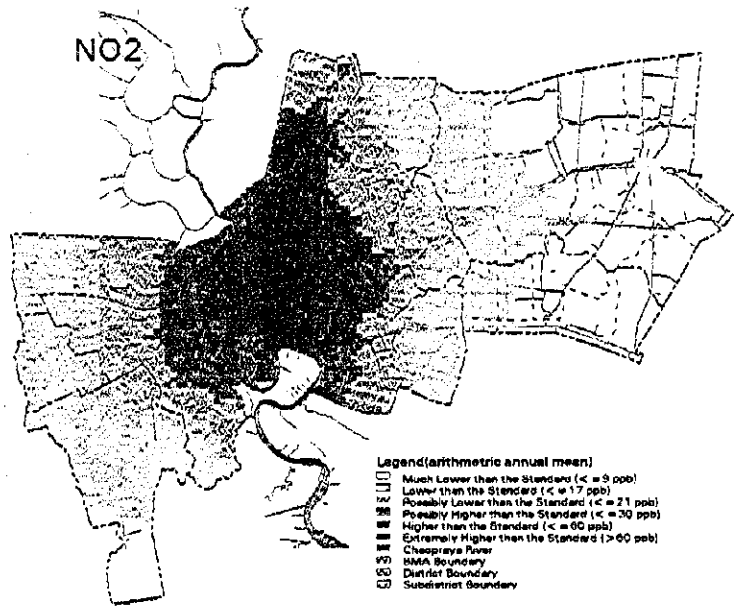
The area of the top 20 grid cells of concentration includes the areas along the expressways and part of the built-up area. Most of the areas are in the Ratchathewi district, on the First Stage Expressway from Din Daeng to Khlong Toei, and on the Second Stage Expressway from Din Daeng to Samsen. Expressways with many lanes and heavy traffic could be the reason of high concentration in the urbanized area.

Fig. 6.5





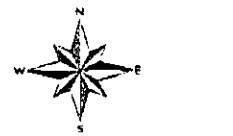




Air Pollution Simulation

Case 1

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



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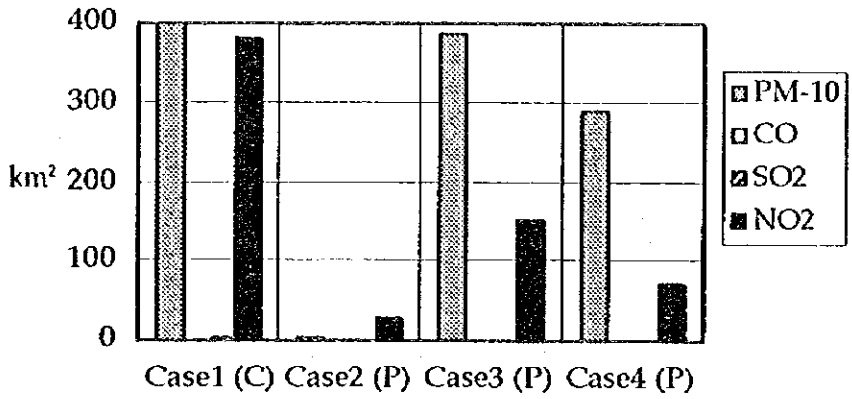
(2) Comparison of Future Probable Policies (P) (Case 2 -- Case 4)

According to the simulation results of Case 2 to Case 4 as shown in Fig. 6.6, exhaust gas regulations are much most effective. Air pollution in Bangkok would be almost acceptable if the exhaust gas regulations were implemented already, as shown in Case 2. Both New and In-Use Vehicle Regulations are indispensable.



Source: BEIP Study Team

Fig. 6.6 Area of "Higher than the Standard" and "Extremely Higher than the Standard" of Case 1 to Case 4 (km^2)

The second effective policy is implementation of the Mass Transit Master Plan. (Case 4). Road construction of the 8th National Plan is not so effective for the PM-10 problem, although it is effective for NO_2 air pollution (Case 3).

1) Recommendations for Future Vehicle Emission (P)

New regulations can be actualized as the vehicle manufacturers have already developed vehicles meeting the EC regulations. However, actualization of in-use regulations seems to be difficult.

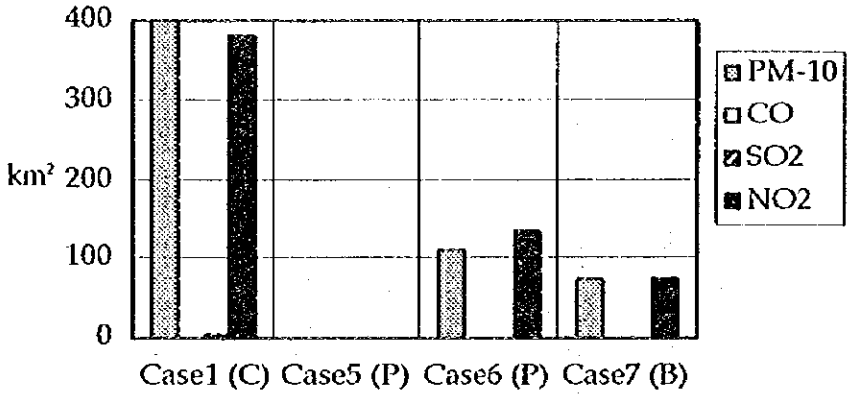
The inspection system, which may include the only major existing regulations for in-use vehicles, has already been applied to all buses. However, the inspection system is apparently not as there are many buses that do not meet the In-Use Vehicle Regulations, although all vehicles would have passed the inspection several months before. For example, 3,291 buses were fined for violating the standards in 1995 (Bangkok Post, Apr. 29, 1996) although the number of the registered bus was only 24,364 at Dec. 31, 1995 (LTD, 1996). The problem might be that many vehicles are inappropriately maintained even they passes periodical inspection.

A daily maintenance program should be strengthened first. An exhaust gas checking program should be applied more frequently than the checking which is carried out under the existing inspection system, and the fine system should be strengthened.

(3) Effect of Transport Demand Change (Case 5 -- Case 7)

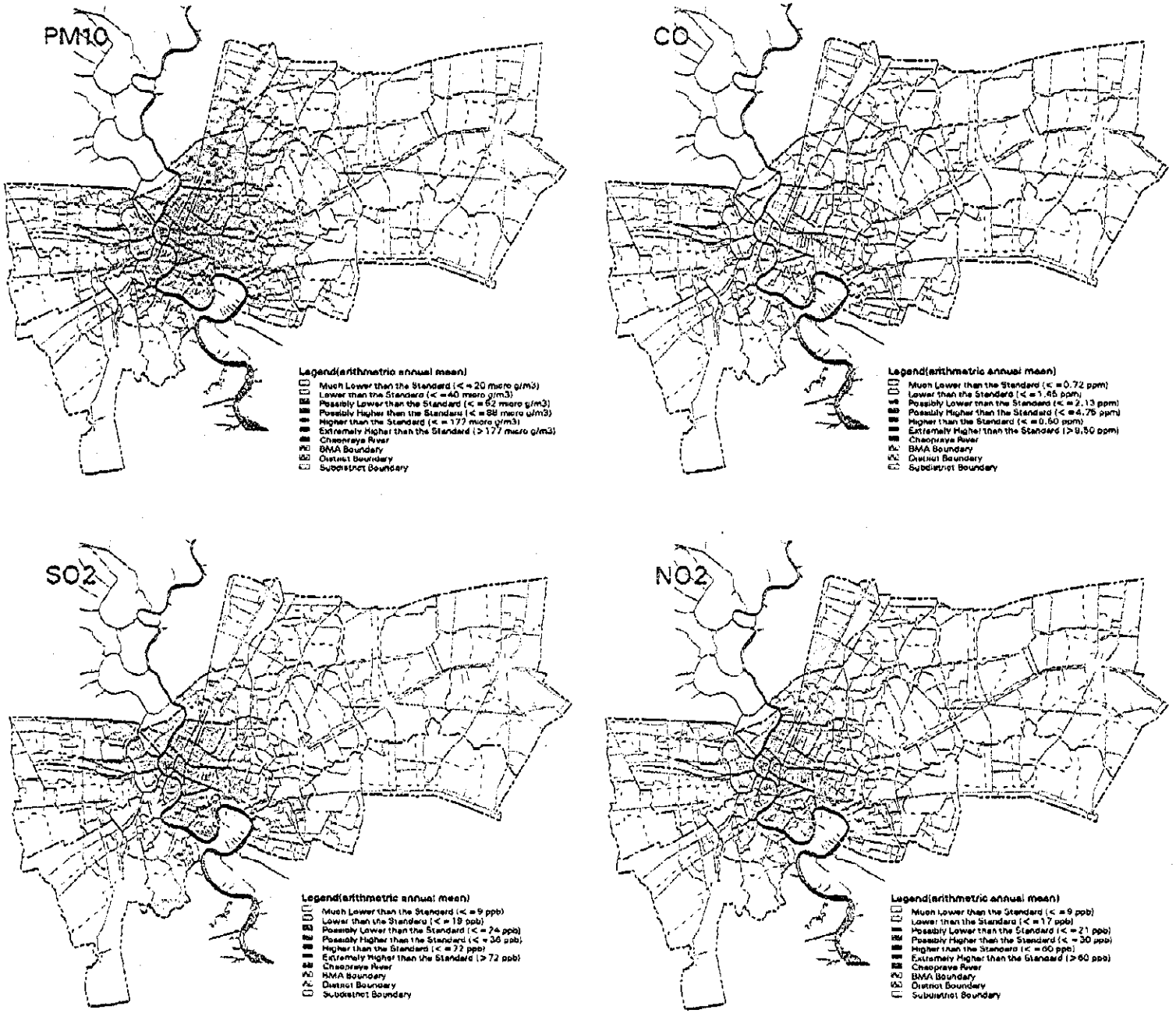
Most of the points in Bangkok would not be rated as "Higher than the Standard" nor "Extremely Higher than the Standard" if all the policies already discussed were implemented by this time (Case 5, shown in Fig. 6.7 and Fig. 6.8). However, Case 6, shown in Fig. 6.7 and Fig. 6.9, shows that even if all these policies were introduced, the situation in Bangkok would not sufficiently improved by the 2011. The increase of the

transport demand would cancel the effect of mitigation policies. There will still be over-standard areas even under the sub center development (Case 7, shown in Fig. 6.7 and Fig. 6.10), proposed by this BEIP Study Team. Further policies for controlling air pollution are required.



Source: BEIP Study Team

Fig. 6.7 Area of "Higher than the Standard" and "Extremely Higher than the Standard" of Case 1 and Case 5 to Case 7 (km^2)



Air Pollution Simulation

Case 5

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

N
W
E
S

SCALE 1:470000

5 0 5 10 15 20

KILOMETERS

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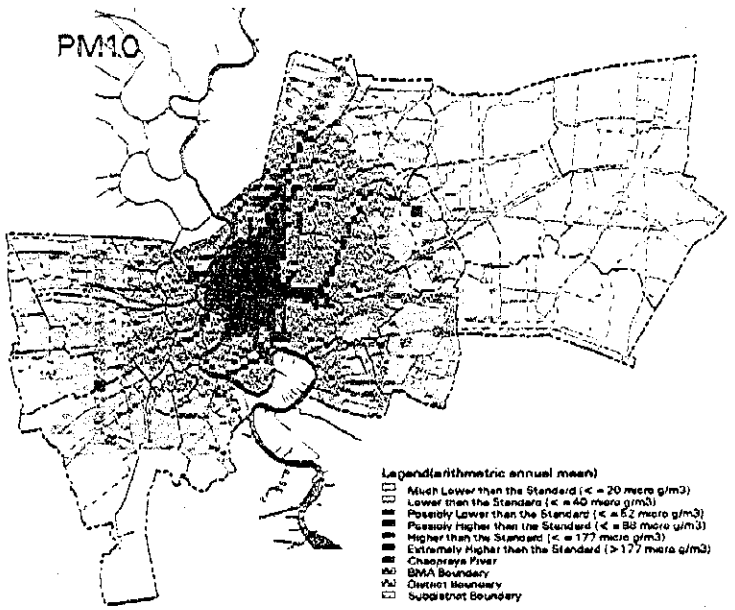
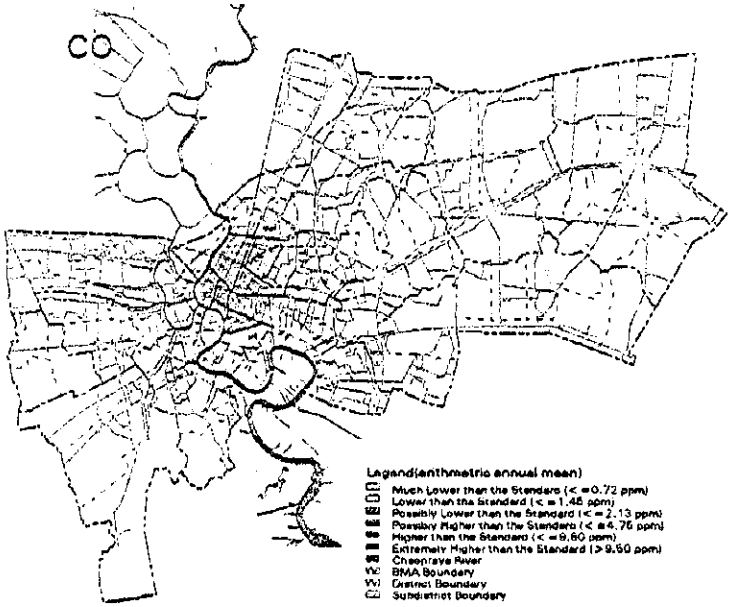
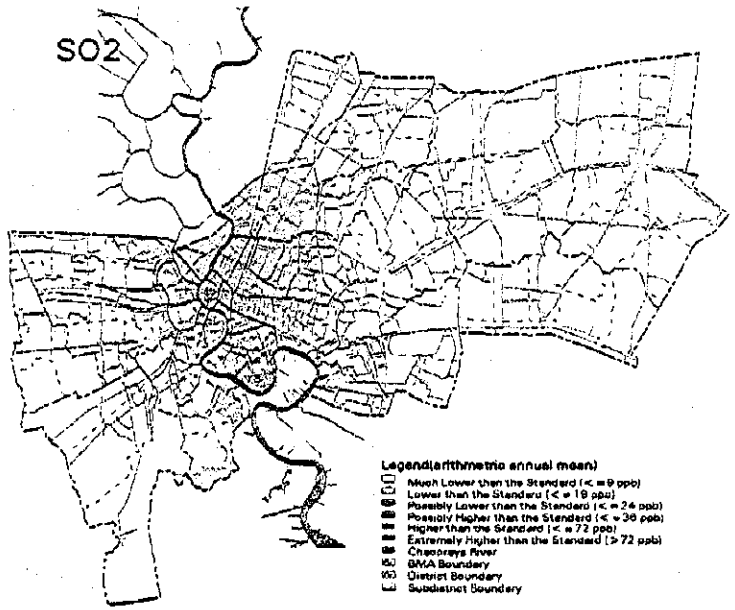
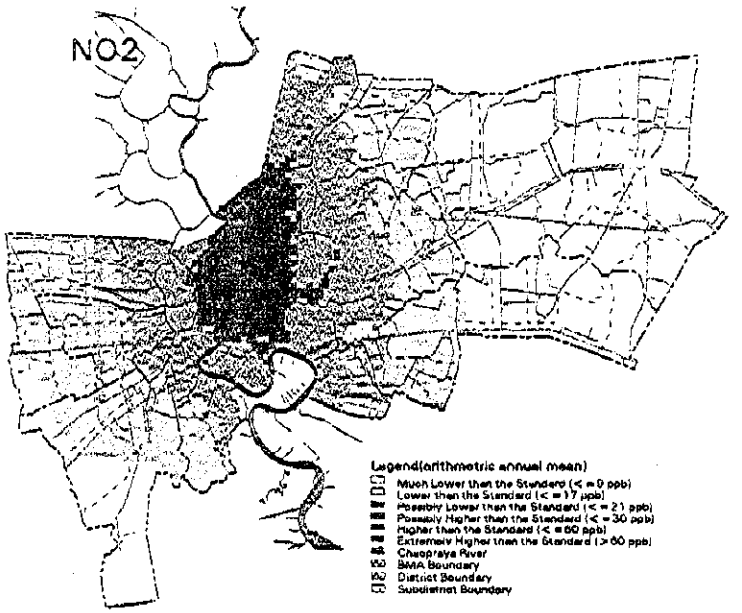




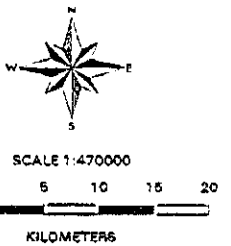




Air Pollution Simulation

Case 6

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



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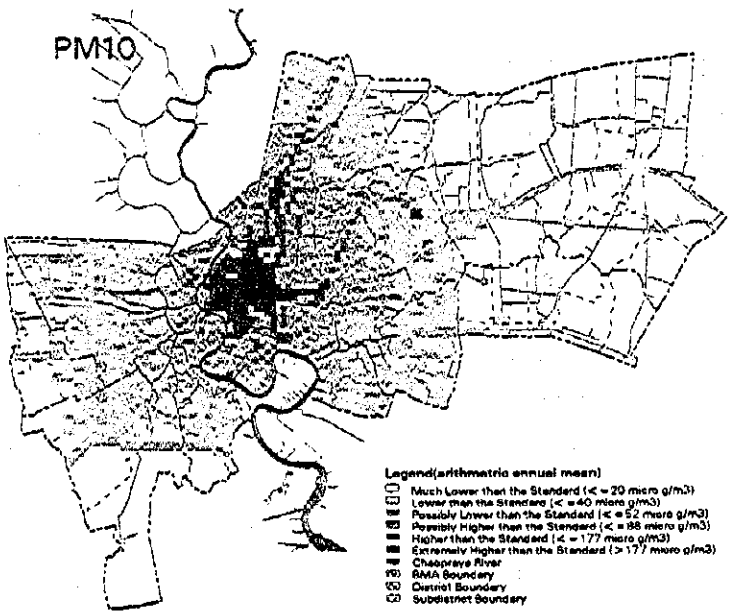
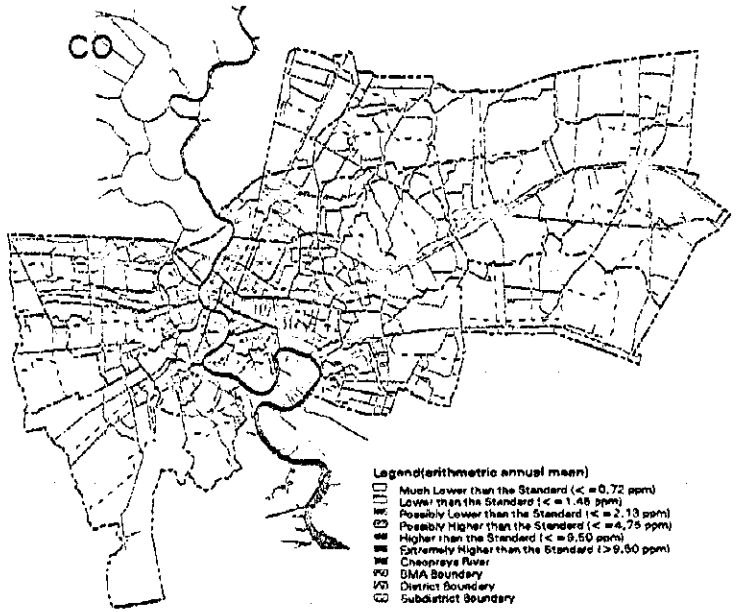
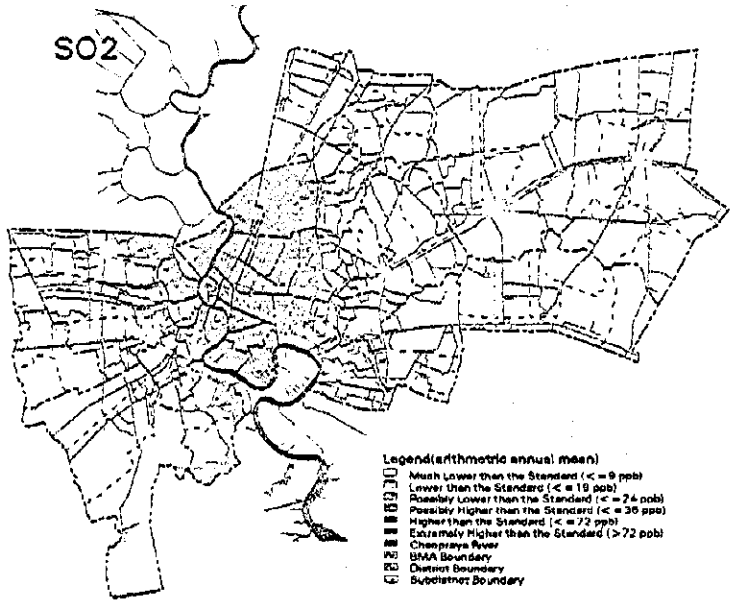
Air Pollution Simulation

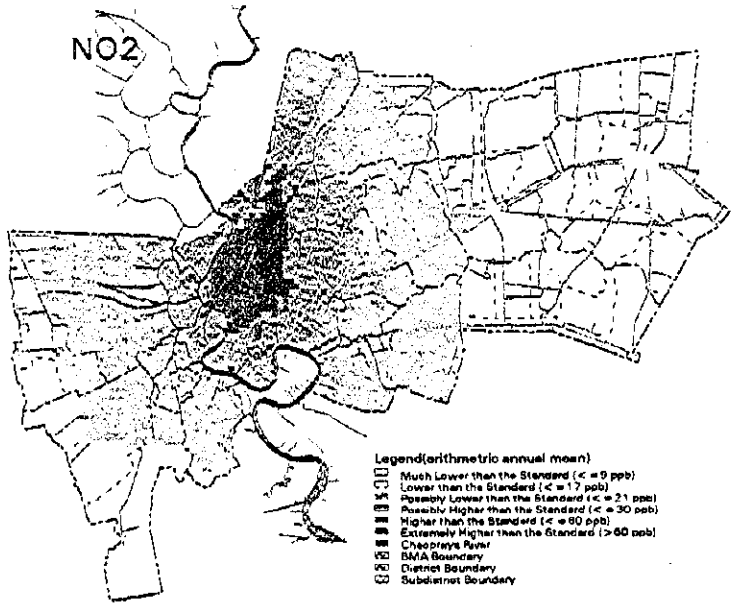
Case 7

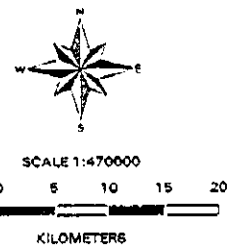
Future Vehicle Emission Factor
Future Road Network
Future Mass Transit Network
Future Transport Demand with
Sub Center Development











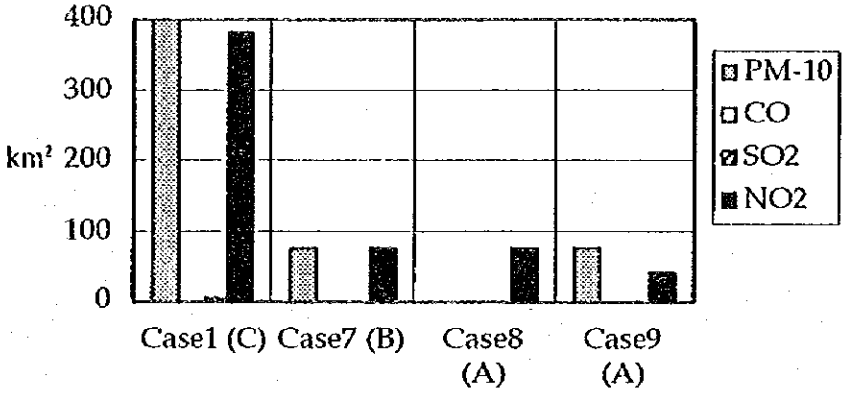
THE STUDY
ON
URBAN ENVIRONMENTAL IMPROVEMENT PROGRAM
IN
BANGKOK METROPOLITAN AREA (BEIP)

BANGKOK METROPOLITAN ADMINISTRATION(BMA)
THE GOVERNMENT OF THE KINGDOM OF THAILAND

JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)

(4) Importance of Additional Future Policies (Case 7 -- Case 9)

Case 8 shows that the PM-10 problem of Case 7 could be mainly solved by the Extreme Modal Shift to buses as shown in Fig. 6.11, although this shift requires a strong administrative initiative and a change of transport network. Case 9 shows that an increase of low-emission buses, such as the CNG type could be effective for pollution mitigation as shown in Fig. 6.11.



Source: BEIP Study Team

Fig. 6.11 Area of "Higher than the Standard" and "Extremely Higher than the Standard" of Case 1 and Case 7 to Case 9 (km^2)

6.7 Implications from the Simulation Analysis

As mentioned above, important factors to improve air pollution are as follows:

- New Vehicle Regulations, starting as soon as possible;
- In-Use Vehicle Regulations, with effective measures such as sufficient maintenance program, exhaust gas checking programs more frequently than the existing inspection system, and an incentive and fine system;
- Implementation of the Mass Transit Master Plan;
- Road construction of the 8th National Plan;
- Demand control by Sub Center Development proposed by this BEIP Study Team;
- Further air pollution mitigating plans, e.g., the modal shift from private to public transportation, introduction of lower emission vehicles than required in the current regulations.

CHAPTER 7: A SUMMARY OF FINDINGS FROM THE SIMULATION ANALYSES

7.1 Environmental Problem Linkages

As demonstrated by the simulation analyses in the preceding sections, all the sector problems are mutually linked with each other, as shown in Fig. 7.1. Since the origin of environmental pollutant loads in the city as a whole come from residents, all the environmental planning arguments are attributed to two aspects: 1) Bangkok urbanization pattern represented by population and land use; and 2) people's living behaviors.

Demands for traffic generation/attraction depend on the urbanization pattern, and affected by people's quality of living and potentials of the socioeconomic activities. This directly affects air quality conditions.

Planning of public service facilities is also dependent directly upon the urbanization pattern, and the existing master plans should be reviewed and revised, if necessary, based on the human settlement patterns.

Thus, outputs from the simulation are inputs for another sector analysis. The simulation analyses are based on such a problem linkage.

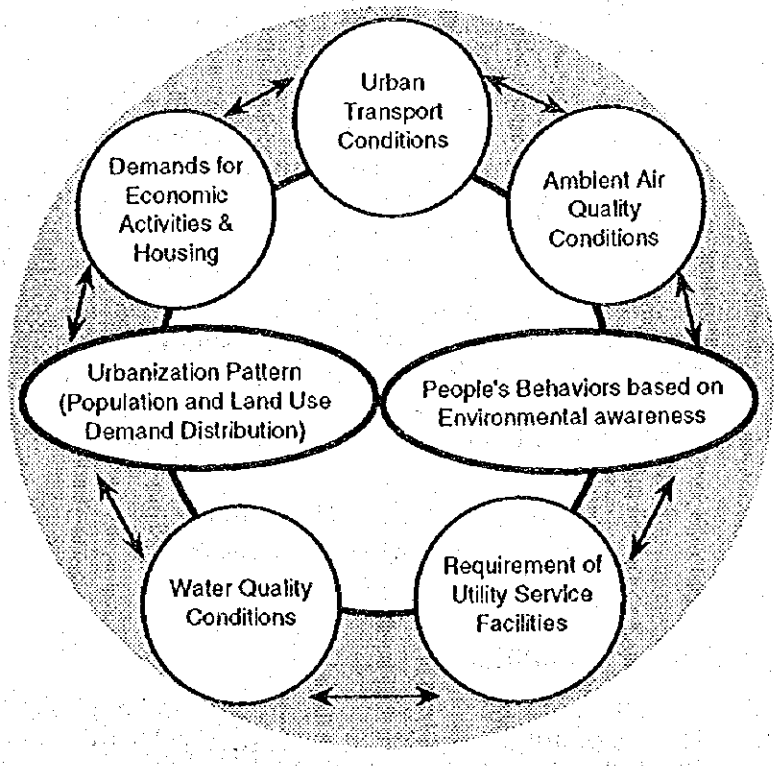


Fig. 7.1 A Linkage Structure among Urban Environmental Problems

7.2 Implications from Simulation of Most-likely Cases

A strong policy is necessary to shift the current movement of development towards the balanced urban growth while minimizing the further environmental deterioration in Bangkok. This is implied from the results of the simulation analysis on the most-likely case.

(1) Most-likely Urbanization in 2011

A total of 343 sq. km will be additionally demanded for the land areas for future urbanization to accommodate additional 2.37 million people up to 2011. Without additional polices to effectively manage land use, the further urbanization will take place mostly in a form of "Ribbon Development" along selected seven corridors with a radial pattern, and areas between the corridors will be gradually occupied for residential use without adequate infrastructures.

Since urbanization is likely to be led significantly by road transport infrastructures, the existing plans of highways will stimulate urbanization pressures along the highways, thereby offsetting the regional benefits. This pattern will worsen the current environmental state.

(2) Most-likely Road Transport Conditions in 2011

At present, as of 1995, out of the total road length of 1,732 km within BMA, 663 km, or 38%, are assessed to be heavily congested in morning peak hours.

Given a hypothetical assumption that the road projects committed for the 8th National Plan with additional 664 km, including ETA expressways, DOH and BMA roads were provided at present, the heavily congested roads would be reduced to half, or 354 Km. Furthermore, given an additional assumption of the completion of MRT systems, the length of heavily congested roads would come down to 219 km. Thus, the planned road projects and MRTs are significantly effective to mitigate the road congestion on the present demand structure. **This means that those planned projects should have been implemented 10 years earlier.**

As far as urbanization is assumed to progress in the trend pattern up to 2011 as mentioned above, transport demands in 2011 will be generated in a way to concentrate further traffic flows into the central area. This will worsen the road congestion than the current state, even if all the existing planned road projects are completed, that is, 1,389 Km out of 2,376 Km, or 59 % of the total roads indicates will be severely congested, and the Congestion Index (CI), compared to CI = 100 at present, accounts for 152.

The on-going projects of MRTs are expected to contribute greatly to mitigation of the traffic congestion in the future. However, the simulation analyses indicates a pessimistic result against this expectation. Even if all the core projects of MRTs were completed in association with the planed highways in 2011, the road traffic congestion would still be in a serious condition: CI is 121 which stand for more congested than the present state.

This result means that the projects of the 8th Plan will be too short to mitigate the road traffic congestion in the future. More effective policies and measures are needed to tackle with this issue.

(3) Most-likely Air Quality Conditions in 2011

PM-10 (or SPM) and NO_2 are the most serious pollutants in Bangkok, which are caused by road traffic. The air pollution simulation analysis reveals that most of the built-up areas are covered with the air with significantly higher concentration of PM-10 and NO_2 than the Thai environmental standard. This assessed to be a serious condition.

The level of air pollutant loads are determined by three factors: 1) average travel speed; 2) traffic volume, especially heavy vehicles; and 3) emission factors. Without any policy to tackle with these factors, the state of air quality in Bangkok will obviously be worsen and broaden, along with extending traffic congestion areas.

7.3 Implications from the Policy Input Cases

(1) Guided Urbanization

As far as the current spontaneous urbanization, or urban sprawl, is allowed, the pressures of urban environmental pollution would not be released and be further concentrated in the central areas. An orderly urban land use system should be pursued by growth management policies with definite guidelines for environment-oriented urbanization.

For this purpose, the simulation analyses implies that one third of land development demands additionally occurring in the future should be guided to areas in subcenter zones where deliberate development with adequate environmental infrastructures, discussed in Sections 9.4 and 24.1.

(2) Effectiveness of Transport Polices

As discussed in Chapter 5, in addition to the transport projects committed by the 8th Plan, four polices/strategies are employed for the simulation analyses to identify the effectiveness on road traffic congestion:

- Bus Priority;
- Road Capacity Increase:
- Area Restraint
- Subcenter Development

In terms of Congestion Index (CI), the most effective strategy is assessed to be "Bus Priority Policy", followed by "Area Restraint" and "Subcenter Development". The bus priority policy and the area restraint policy may be materialized with institutional arrangement plus minor additional investment on the infrastructures. On the other hand, "Subcenter Development" needs a strong initiative of the government sector and requires a massive investment for long time.

It should be noted that "Road Capacity Increase" would not contribute to mitigation of traffic congestion in the city as a whole, because more roads result in more traffic flows into the central areas.

An important implication derived from the above is that in order to improve the road traffic conditions, a policy mix placing high priority on the following are indispensable:

1) Bus transport system in association with MRTs;

2) Area control in the central area; and

3) Subcenter development to disperse the traffic generation/attraction structure.

(3) Effectiveness of Air Pollution Control Policy Mix

The simulation analysis also provides a planning implication that without a considerably sever policy mix, the air pollution cannot be mitigated to be under the designated standard level in terms of PM-10 and NO_2.

The simulation analysis reveals that given the urban re-structuring policy strengthened by a shift to the public transport-oriented system as well as "Subcenter Development" the air pollutant diffusion pattern in 2011 would be significantly changed. Despite that in the central area there will still exist a number of areas with higher concentration of

PM-10 and NO_2 than the standard, the air condition of Bangkok will be improved as a whole.

Therefore, it can be said that the following policy mix will be effective to mitigate air pollution caused by road traffic.

1) Travel speed up on road traffic in the inner city;

2) Significant shift of passengers from road transport to MRTs; and

3) Strong vehicle emission regulation policy (as the European standard).

The first and second factors all depend greatly on the urban structure and the transport system.

PART III: MASTER PLAN OF URBAN ENVIRONMENTAL IMPROVEMENT

CHAPTER 8: POLICY DIRECTIONS AND A SCENARIO OF URBAN GROWTH

8.1 Economic Growth with Environmental Preservation

Once Bangkok has already cleared a hurdle against the self-sustainable economic growth, it has now confronted with another crucial paradigm to seek an environmentally sustainable economic growth. A question is no longer of selection of which policy should be emphasized, the economic growth or the environmental preservation. The issue is to formulate a balanced system between both, based on a recognition that the economy must be part of the environmental system. In this regard, several arguments are viewed, prior to discussions of planning.

(1) Urban Economic Activities and Energy Consumption

Energy consumption, particularly use of fossil fuels, in economic activities, is a significant source of the environmental deterioration. Economic growth has always been putting pressure on environment of the city, however, environmental pollution of the city does not always increase at the same rate with the economic growth, looking into the other countries.

Fig. 8.1 compares the growth rates of the final energy consumption in relation with the level of GDP per capita in major countries over the world. It is generally observed, in fact, that along with the growth of per capita GDP, energy consumption per capita accordingly increased, and that the energy consumption per unit GDP is higher in lower income countries than higher income countries. For instance, while the per capita GDP of Japan as higher than that of Thailand by 15 times in 1993, the final energy consumption per capita of Japan was 5 times as large as that of Thailand. Consequently, it was 2.55 and 0.50 ton oil equivalent (TOE) per unit GDP in Thailand and Japan respectively.

Moreover, looking into city solid waste generation in comparison with major world cities, the garbage generation per person per day in Bangkok amounts to approximately 800 grams at present, which is the similar level to that in London, as shown in Fig. 8.2. It may be said that Bangkok is now the first class city in terms of garbage generation and energy consumption.

It is undoubted that the energy-consuming economy will be losing its international competitiveness in the near future, because the social costs will have to be paid by the economy itself. Therefore, Bangkok needs to formulate anyhow the more energy-saving economic system to maintain both environmental and economic sustainability with more emphasis than other cities in advanced countries.

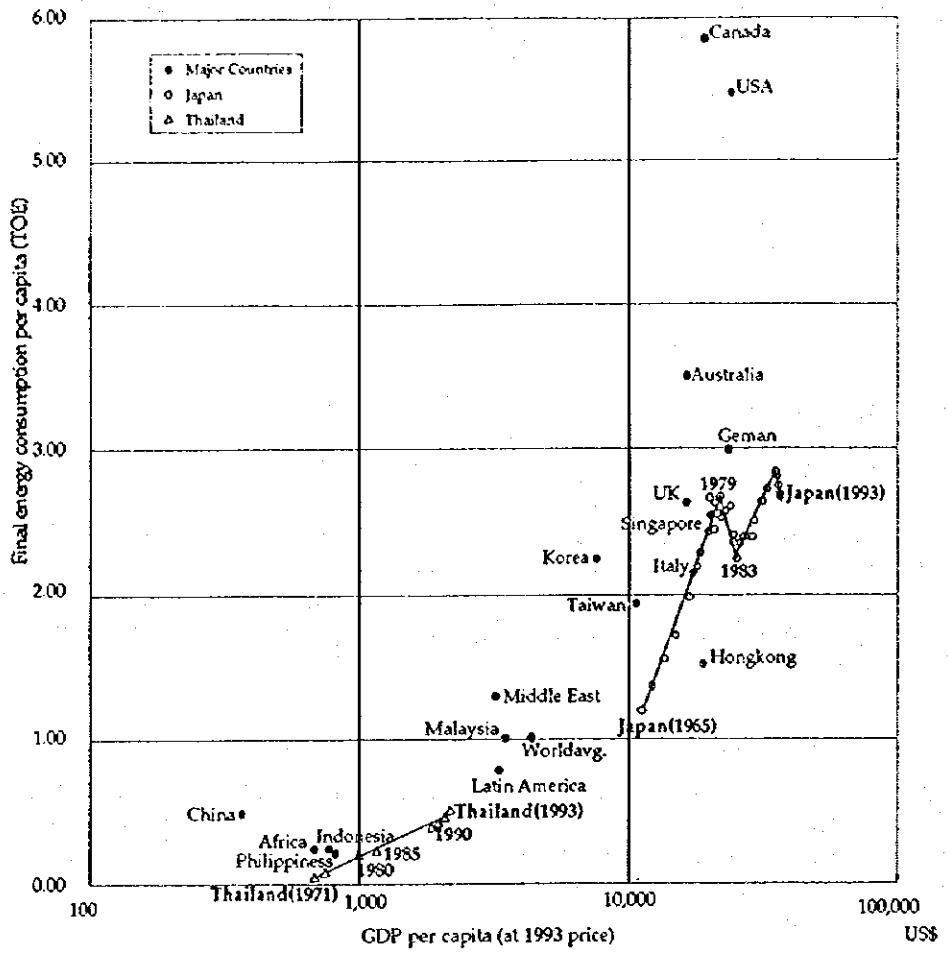


Fig. 8.1 Correlation between Per Capita Final Energy Consumption and Per Capita GDP Growth

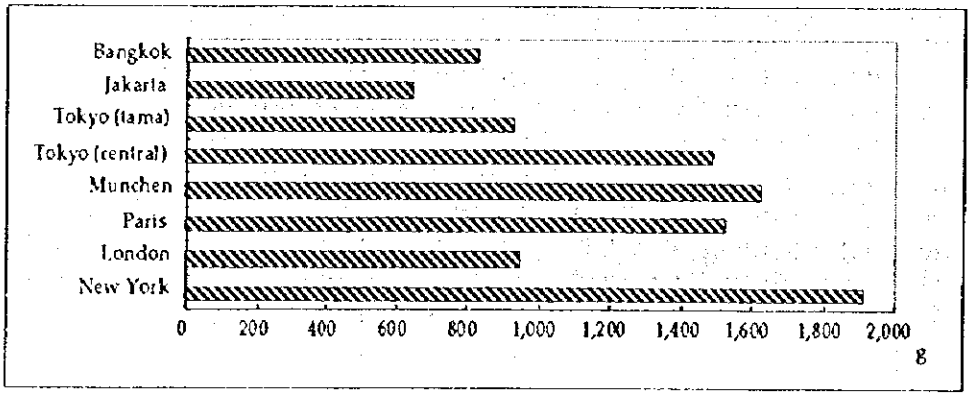


Fig. 8.2 Comparison of Per Capita Garbage Generation

(2) People's Awareness: More Economic Growth or Environmental Preservation

Nowadays, the majority of Bangkok people have already recognized the importance of environmental preservation at the cost of slow-down of the economic growth. This was identified by the Interview Survey on Environmental Awareness to a total of 3,000 Thai people, of which 1,000 are in Bangkok, conducted by Institute of Developing Economies (Japan) in September to December 1994. A Summary of the results are as shown in Table 8.1, and the following are suggestive findings from the survey:

- 59% of Bangkok people have an opinion that environmental protection is more important than economic growth, while 25% select economic development rather than environmental protection;
- Out of prevailing environmental problems, Bangkok people consider that the most serious is "Air Pollution (44%)", followed by "Deforestation (28%)" and "Water Pollution (14%)";
- 41 % of Bangkok people recognize "Deterioration of the Environment" as the most serious social problem, followed by "Rife Corruption and Bribery" (25%); and
- The majority of Bangkok people, or 69%, feel significant apprehension on health and life by the environmental deterioration.

It can be said, based on the survey results, that the environmental improvement must be now the most concern among Bangkok people.

Table 8.1 A Summary of Environmental Awareness Interview Survey

	%
1. People's Awareness regarding Urban Environment:	
Environment VS. Economic Growth	
"Which do you think more important "Economic Growth or Environment"	
1) Environment	59
2) Economic Growth	25
3) Both	16
2. Most Serious Environmental Problems in Bangkok	
1) Air Pollution	44
2) Deforestation	28
3) Water Pollution	14
4) Garbage	6
5) Food	3
6) Drought	2
7) Noise Pollution	2
3. Most Serious Problems in Thai	
1) Natural/Environmental Deterioration	41
2) Rife Corruption and Bribery	25
3) Too Big Gap between the Rich and the Poor	14
4) Lack of Respect for the Superious and the Elderly People	7
5) People are Less Religious	7
6) Good Family Background is an Advantage for Job Opportunity	7

Source: Environmental Awaareness Survey, September - December 1994, IDE

(4) Policy Framework of the 8th National Economic and Social Development Plan

National Plan and Environmental Legislation

During the initial stage of the economic growth in Thailand, degradation of environmental quality was not considered as a critical constraint against sustainable development. The national government executed the environmental legislation with a rather small scale. Consequently, the environmental quality had not been functionally managed in urban areas and in tourist spots to exceed the people's acceptable level.

Results of the Sixth National Plan (1987-1991) brought about the economic growth with a respectable degree of stability, security and a generally better standard of living of the people. However, such high economic growth had led the Thai society to the distortion in the economic development in association with the environmental quality degradation.

The Seventh National Plan (1992-1996) formulated definite policies on environmental development to improve the situation of public nuisances for better quality of life. And, at present, a number of the environment-related projects are currently being implemented.

In 1992, the Government established a new ministry, Ministry of Science, Technology and Environment (MOSTE), reorganizing the existing governmental agencies and offices to execute the revised act, Enhancement and Conservation of the National Environmental Quality Act-1992 (called "the Environmental Act"). Pollution Control Department (PCD), MOSTE, takes principal roles for environmental projects/programs though it is required to have well coordination and close cooperation among other relevant implementing agencies of environmental projects. The current legislative framework consists of the following acts:

Environment-Related Acts	Enacted Year
• National Environmental Act (Enhanced)	1992
• Public Health Act	1992
• Public Cleansing and Orderliness Act	1992
• Factory Ac	1992
• Agricultural Land Use Act	1975
• Royal Thai Irrigation Act	1975
• Land Development Act	1983
• City Planning Act	1975
• Industrial Estate Act	1979
• Toxic Substance Act	1992
• Ground Water Act	1977
• BMA Act	

Table 8.2 summarizes the major aspects regulated by the environmental quality acts.

Past Performance of Environmental Policies

In the Seventh National Plan (1992-1996), the main objectives of development had been articulated: 1) Maintain economic growth with sustainability and stability; 2) Distribution of income and decentralization; and 3) Development of human resources, upgrading quality of life, environment and natural resources management.

Base on the Plan, six sewage projects in Bangkok, started, but only one, Sipraya Waste Water Treatment Plant, has been completed at present. The Khlong water quality improvement project in the central area in BMA, of which the construction work started in 1993, made the less than 20 % work performance during the last 2 years.

For the smooth implementation of environmental projects such as solid waste incineration projects, the mutual trustworthy relation is needed among the executing agency and neighboring communities of the project site, as represented by the Chiang Mai project. Involvement of activities of NGOs and/or communities from the early stage is essential, otherwise, the project implementation is subject to delay.

Meanwhile, the air quality monitoring work executed successfully with 18 stations in the whole country, including 8 stations in Bangkok to monitor the real time air quality. However, few practical measures have been undertaken based on the monitored data.

Due to the delay of environmental development projects in the Seventh National Plan, the environmental quality in air, in water, in solid waste, etc. have not been improved yet.

Environmental Policy of the Eighth National Plan

The Eighth National plan (1996-2001) was recently released in public. The Plan includes a number of policy requirements for rational management of natural resources, priority accorded to the environmental protection and conservation, and restoration of natural resources on the basis of sustainable and balanced development between economic growth and human life. Measures for materialization of the Plan are summarized as follows.

1) Establishment of Community Participation: by decentralizing the implementation of environmental development to the provinces and to the local communities;
2) Cooperation for Development: with environmental legislation for development based on a "polluter-pay-principle" applied to project owners and beneficiaries by using economic tools to ensure feasibility of the project; and
3) Encouragement of Scientific and Technical Development: by development of human resources, support of clean technology, and support of private sectors for green products.

(5) Policy Framework of the 5th Bangkok Development Plan

The main environmental policy of the Fifth BMA Plan (1996-2001) has just been formulated, aiming to achieve the policy targets as follows:

- Investment on construction of environmental infrastructures and continuous expansion works;
- Human resources development on both BMA and publics through information and participation on environmental problems;
- Beneficiaries side management based on the polluters pay principle;
- Rational management of urban development harmonized with environmental conservation; and
- Promotion for privatization in environmental development.

All the policies are assessed to be on the right way. The Plan includes a list of projects/programs for implementation with five categories during the period of Fifth BMA Plan: 1) development of overall environmental conditions; 2) drainage and flood protection; 3) waste water treatment; 4) solid waste and hazardous wastes management; and 5) air and noise pollution abatement. Table 8.3 shows a draft of the projects/programs to be stipulated in the Plan.

Table 8.2 Environmental Legislative Framework in Thailand

Acts	Regulated Categories	Stipulated Items/Aspects
The National Environmental Quality Act	• Empowered Authority and Duties of National Environment Board; • National Environmental Funds; • Environmental Protection • Environmental Quality Standards • Environmental Quality Management Planning • Conservation and Environmentally Protected Area; • Environmental Impact Assessment • Pollution Control Committee; Emission or Effluent Standards	• Pollution Control Area; • Air and Noise Pollution; • Water Pollution; • Other Pollution and Hazardous Waste; • Monitoring , Inspection and Control; and • Service Fee and Penalty; • Pollution Control, including: • Inducement Measures; • Civil Liability
Air Quality Standards	• National Ambient Air Quality Standards • Industrial Emission Standards • Motor Vehicle Emission Standards • Boat, Ship, & Vessel Emission Standards	
Noise Quality Standards	• Community Noise Standards • Noise Emission Standards • Motor Vehicle Standards • Noise Standard in Workplace by Ministry of Interior and Ministry of Industry	• Boat, Ship & Vessel Noise Standards.
Water Quality Standards	• Drinking Water Standards • Industrial Effluent Standards • Effluent Water Standards • Coastal Water Quality Standards • Surface Water Quality Standards • Building Effluent Standards • Coastal Water Quality Standards • Chao Phraya River Water Quality Standards • Tha Chin River Water Quality Standards • Bangkok, Nakorn Nayor, Prachinburi River Water Quality Standards • Maeklong River Water Quality Standards	• Bottled Drinking Water Quality • Regulation of Industrial Pollution Control Facilities; • Industrial Effluent Guideline for Discharging into Eastern Seaboard Coastal Area (Map Tha Phut Area); • Water Characteristic Discharged into Deep Wells • Classification of Coastal Water • Area Classification for the West Coast of Phuket Island
Solid Waste, Night Soil and Hazardous Waste Stan	• General Solid Waste and Night Soil Management • Solid Waste, Night Soil and Hazardous Waste Management for Factories • Solid Waste Management for Multistory or Large Buildings	• Solid Waste and Night Soil Collection Fee • Solid Waste or Unusable Material • Expired or Unusable Solvents • Solid Waste or Unusable Material from Specified Industries • List of Chemical Waste by Ministry of Industry
Toxic Substance Legislation	• Toxic Substance Limits in Food • Atmospheric Chemical Standards in the Workplace	• Banned and/or Restricted chemicals under the Toxic Act
Nuisance Abatement	• General Nuisance Abatement • Industrial Nuisance Abatement	

Table 8.3 Environment-related Measures in the Fifth Bangkok Development Plan (1996-2001)

	Sector	Major Strategies/Programs
1	**Development of Overall Environmental Conditions**	• Increase green area by planting at unused land in BMA Area • Improvement and restoration of Klongs for effective use • To organize seminar and training for BMA administration staff for understanding of environmental development • Coordination and cooperation with other sectors for environmental conservation
2	**Drainage and Flood Protection**	• Preservation and development of vacant land for retardation of floodwater runoff • Improvement and construction of polder systems in BMA Area, especially in Tonburi and eastern suburbs • Survey and data collection on sub-drainage systems for linking with the main drainage system • Promote support from the government for procurement of retardation area
3	**Waste Water Treatment**	• Completion of on-going projects including leachate treatment plant • Environmental legislation for controlling discharge from buildings • Enhancement of the capability of discharge investigation • Promotion of private sectors for Waste Water management • Improvement of water quality in Klongs Public campaign to combat water pollution for water quality improvement
4	**Solid Waste and Hazardous Waste Management**	• Continuation of existing systems on collection and disposal • Improvement of solid waste treatment plants at On Nut and at Nong Khaem for integrated development • Provision of equipment to increase efficiency in collection, transfer and sanitary landfill • Enhancement for separation of hospital waste from general waste • Promotion of private sectors for solid waste management • Introduction of appropriate service charge and regulations • Staff training for solid waste management
5	**Air and Noise Pollution Abatement**	• Introduction of stringent standards for control of air and noise pollution • Establishment of the centers for coordination and cooperation with other sectors • Public relations on environmental problems

Source: BMA

8.2 A Vision of New Bangkok 2011

Viewing the future, Bangkok will have to confront with a number of changes to be required by the times in its economy and society. Some of conceivable changes are prospected to get future insights into the Bangkok environment as follows:

(1) Knowledge-based international hub city

Thailand has been enjoying a rapid economic growth at more ore less 10% p.a. since 1987, in which the Bangkok economy does and will continuously strengthen its centric and higher urban functions rather than industrial function. More information-based and more value-added types of business with international linkages will be expanded. Appreciating this favorable trend, Bangkok is expected to shift towards "Knowledge-based international hub city" of the Southeast Asia, having the urban environment as good as corresponding to such a reputable city.

(2) A Mega-city with more than 10 million Population

Bangkok is still accepting rural-to-urban migrants at a significant rate, despite a long-standing "Decentralization Policy". Although this increasing trend will cease in the long-run along with the economic growth in regional areas, however, Bangkok will grow to be one of the largest Mega-cities over the world with more than 10 million population in 2011.

(3) Environment-conscious Society

The expected economical development will eventually up-lift the per capita income level to be US$13,000 in 2011, compared to US$5,600 at present as of 1995. As being economically affluent on one hand, people will become more environment-conscious and more cultural identity-oriented on the other hand. Environmental improvement will be a further critical policy issue.

(4) Mass Transit-driven Urbanization

The current energy-consuming structure of the urban transport system will be enforced to be shifted towards an "Energy-saving City" to manage the more efficient and internationally competitive urban economy. To this end, Urban Re-structuring will be a key issue for urban planning, based on "Mass Transit-driven Urbanization". And, the society will call for people's awareness of importance of efficient resource utilization and recycling in process of modernization and up-grading of their living environment.

(5) Public Benefit-oriented Society under Urban Growth Management

"Urban Metabolism" will apparently be more activated in land use, affected by a structural change in demands at real estate and housing markets. The inner urban area will be pressured to be re-generated due to land economization, and suburban areas will be further developed to accommodate increasing land demands. Growth Management System, therefore, will be strictly required to materialize orderly urbanization symbiotic with the environment.

"Laissez-faire" must be a principle of the free economy, and should not be narrowed by anyone. However, under the circumstances that available resources are strictly limited in use and that one's gain is likely to result in worsening the other's welfare, this principle may be somewhat restricted or controlled by the authority. Urban development is the case. Free transactions of land and buildings under the free market is now producing more diseconomies, thereby eventually offsetting the otherwise

would-be-gained economic benefits in the society. Hence, the more Public Benefit-oriented Society needs to be pursued in planning of urban environment improvement.

8.3 Planning Disciplines for Urban Environmental Planning

As proved in many other cities, only technical solutions are sometimes not effective and rather likely to produce another problems. Planning of the urban environment is a task to depict a blueprint of the total urban system itself. Because all urban activities are part of the environment and elements of the environmental dynamic system, the task calls for a sophisticated discipline to incorporate all factors into the total urban system which assures people's quality of living. The following considerations were a basis of the planning.

(1) Pursuance of Sound Urban Environment

Planning of environmental improvement pursues four (4) vital elements of human life, i.e., people's healthy, safe, comfortable and convenient lives.

Healthiness: Clean water, clean air and nutritious foods are substantial and good sleep, proper exercise and hygienic metabolism are essential to maintain people's healthy lives.

Safeness: Being free from any fear and danger on one's individual life should be assured in safe transport, social and food security and no natural disaster.

Comfortableness: People feel comfortable when they live in their inherent socio-culture with the indigenous natural environment.

Convenience: Smooth and efficient access to urban services, work places and schools should be first provided for people within their living spheres.

(2) Sustainable Growth with Economy and Environment

Three principles basically need to be employed for realization of a sustainable economic growth while maintaining the quality of the urban environment:

- An economic principle is needed to be employed to materialize a sustainable development system, that is, a decrease of environmental resource by one unit of economic value shall be compensated with an increase of environmental input by the corresponding value though the economic mechanism. The **polluter-pay-principle** may be justifiable in this sense. Social costs for the environmental improvement should be compensated by the economy itself.
- The manner (or **social rules**) for usage of limited environmental resources is also a focal argument on the community ground. Any type of development should minimize anticipated negative impacts on the environment based on anther principle that one's gain never results in worsening the other's welfare.
- Urban development management needs to be systematized, based on a faith that a preventive approach is less costly than a curative or remedial approach in the long-run. Before worsening the environment, effective measures against it should be undertaken. The sooner, the better.

(3) Functioning Urban Metabolism System

The city itself is of an organic system. The city always changes its land use and functions, in response to requirements of the times and the economy. This may be called "Urban Metabolism".

To maintain the well-functioning metabolism, two sub-systems must work reciprocally: "Anabolism" and "Catabolism".

- *Anabolism* : the city always requires fresh and clean inputs sufficiently enough to maintain the organic system such as water, air and foods.
- *Catabolism*: the city produces as same volume of excrement such as waste water, solid waste and air emissions as inputs which need to be treated, otherwise it would damage the capability of the urban function itself.

Symbiosis of the man-made environment and the natural environment, as illustrated in Fig. 8.3, is a key planning concept.

(4) Urban Growth Management

Every organism inherently knows its limit of growth. The limit is determined as a level that it can manage itself. Alike, the Bangkok Megalopolis needs a urban growth management system. The growth shall be managed within the carrying capacity that the government can manage in providing necessary public services to protect the environment. The carrying capacity is determined by the authorities' managerial and economic capabilities.

More important is development of institutional systems effective for urban growth management as planning administrative tools and/or power. This is one of focal issues in this Study.

(5) A Tripartite Approach for Implementation of Environmental Programs

Without integrated efforts of three parties of the government, economic and social sectors, a sustainable implementation system could not be built to improve the urban environment. as conceptually illustrated in Fig. 8.4. The public benefit-oriented society lies on the ground of reciprocal relations among the three parties whose roles, duties and rights be just performed.

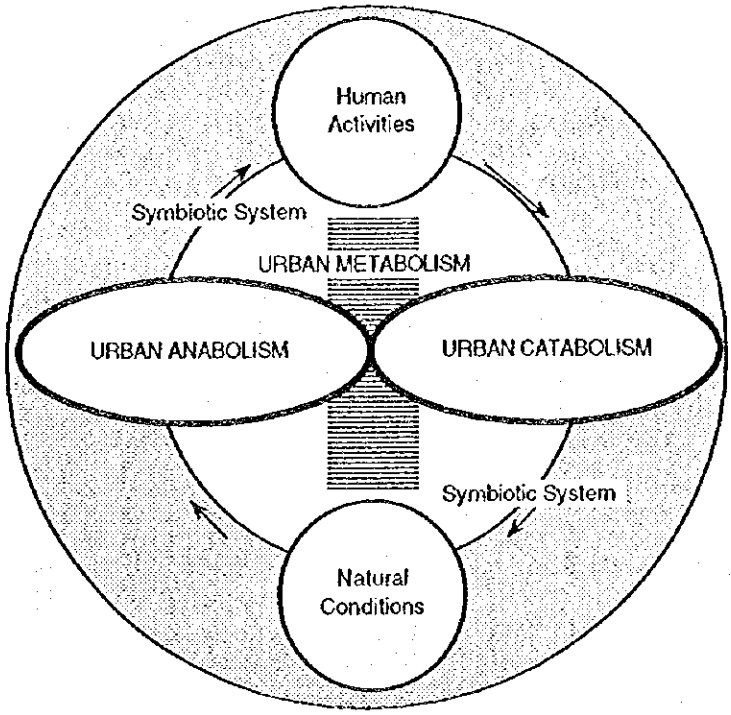


Fig. 8.3 A Concept of Urban Metabolism and Environmental Symbiosis

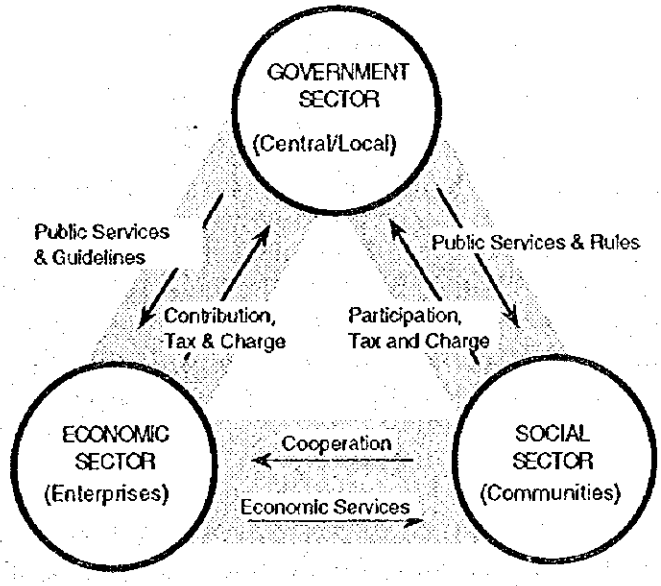


Fig. 8.4 Tripartite Approach Required for Environmental Improvement

8.4. Socioeconomic Framework: A Urban Growth Scenario

Viewing the future, it can be predicted that Bangkok will continuously function as a prime city, strengthening its centric and higher level functions rather than industrial function. Moreover, international linkages with the world market through rapid development of information networks and business transactions will be further strengthened, and the Bangkok economy will have a prime role of its performance. Such a functional shift will make "New Bangkok" in the medium-term.

On the other hand, decentralization of urban activities will gradually proceed over its surrounding regions in the medium- and long-term, as diseconomies from the economy of agglomeration become more apparently severe in Bangkok.

Table 8.4 summarizes the results of projections of the socioeconomic activities in the future till 2011, based on the above perspectives. The sector discussions are as follows:

(1) Urban Population

The 1995 Population of BMA cannot be accurately identified, having a great difference among the statistical data and several projections made by relevant studies: 5.6 million (based on the registration data) to 8.3 million (projected by the UTDM project team). However, it can be safely said from several evidences that the increase rates of the Bangkok population are gradually decreasing, while the population in the regions outside Bangkok, BMR, is considerably increasing.

The pressure of population increase will be gradually released in Bangkok in the long-term. Instead, a more strong pressure will appear on urban restructuring aiming at more efficient and comfortable urbanization. In the year 2010, the Bangkok population will reach around 10 million, compared to the 1995 population of approximately 8.0 million. This projection was made in coordination with the UTDM Project team, based on the a most-likely case study.

Thus, the urban physical and spatial framework to accommodate this 10 million population should be functionally structured toward the target year 2011.

(2) Projections of the Economy and Household Income

Gross Provincial Product (GPP) of Bangkok

The Bangkok economy is growing at a two digit rate, or 12% p.a., during the period between 1989 ad 1991. It can be said that supported by the economic foundation of Bangkok which has been increasingly strengthened for the last decade, such a favorable momentum of economic growth will continue in the short-term despite some fluctuation of the world economy, led by the private sector's active investment onto new business sectors. However, along with the economic maturity in the medium- and long-term, the economic growth rates will come down to a moderate level, say, 8 - 6 % p.a.,

Based on this prospect, GPP (at 1988 prices) of Bangkok was projected at 2,557 billion Baht in 2006 and 3,422 billion Baht in 2011, compared to the projected 1995 figure of 1,149 billion Baht. The economy will become 2.5 times as large as that at present in the nest one decade, and triple in 2011.

Per Capita GDP

The per capita income level of Bangkok has drastically been increasing at 8-10 % p.a. for recent years. The growth rates of per capita income is identical to the difference between growth rates of the economy and the population. Eventually, the per capita income (at 1988 prices) will account for approximately 261 thousand Baht (or equivalent to US$ 10,400) in 2006 and 326 thousand Baht (or equivalent to US$ 13,000) in 2011.

Average Monthly Household Income

The BEIP team conducted the Home Interview Transport Survey with a total of 4,000 families over BMR in 1995. Adding to the same survey by the UTDM team with 4,000 families, we have the 8,000 families' transport data base, which can provide with a number of social attributes of families in BMR. From the data base, the average monthly household income in 1995 can be identified to be 21,032 Baht. Taking into account the growth rate of per capita GDP and a decreasing trend of household size, the average monthly household income will be approximately 33,802 Baht in 2011 at a 3.0% p.a. growth rate between 1995 and 2011.

(3) Urbanization and Land Use

The above movements as seen in the Bangkok economy will encourage a "Urban Metabolism", which will encourage physical changes in the urban land use pattern, affecting the demand structure of the real estate market such as commercial, office floor and housing markets. Industrial facilities locating in the inner areas will be rationally enforced to be relocated towards suburban areas.

The present urbanized area as of 1995 is projected at approximately 541 sq. km, or 34.3% of the total BMA area. Future demands for land use are determined by several dynamic factors: 1) increases in number of households; 2) up-grading of housing requirements; 2) demands for the would-be-rebuilt houses/buildings; 3) regeneration of the high density areas in the inner city; 4) manners of housing development; 5) provision of infrastructures and so on.

The BEIP team projected the future demands for urban land use based on a urbanization simulation analyses, as discussed in Chapter 4, taking into account selected factors out of the above. As the result, the urbanized area will account for 884 sq. km in 2011, or increase by 343 sq. km in coming 16 years from 1995 till 2011.

The urbanization ratio, in terms of percentage of urbanized area to the total, will be 56% in 2011, compared to 34% at present. It is assessed that Bangkok will reach a limit in its carrying capacity to accommodate the anticipated urbanization by 2011, taking into account the necessary open space to manage water.

Looking into changes in the population densities in urbanized areas, a gradually decreasing trend will appear, that is, about 150 persons/ha in 1995 and about 12 persons/ha in 2011. This implies a more horizontally spreading urbanization pattern. This comes from a reason that along with the development of infrastructures such as MRTs and highways, the urban potential areas will be gradually expanded in the future.

(4) Motorization

As of 1993, the number of all types of registered vehicles, except motorcycle, accounts for about 1.55 million, or 0.2 vehicle per capita. The number of registered motorcycles was 1.1 million in the same year.

It has broadly been proved that the car ownership grow proportionally in correlation with the economic growth. In fact, the car ownership elasticity of GPP in BMA is computed at 1.1 between 1991 and 1993, and 0.77, between 1989 and 1991, reflected by predominant increases since 1991. In fact, motorization in Bangkok has recently been full-blown, due to up-lifting of income levels in association with reduction of the tax.

As for the future prospect, two cases are conceivable:

Case 1: If the supply side provision can keep up with the demand in the future, in other words, if the traffic congestion and other external factors cannot become any constraint against vehicle ownership, the number of vehicles would increase elasticity (at the elasticity of 1.0 to 1.1) with the economic growth in the future. In this case,

approximately 4.5 million vehicles, except motorcycles, will be registered in 2006, and 6.1 million in 2011.

Case 2: If some strategies and measures effectively can restrain the vehicle ownership by providing a well-functioning mass-transit systems as an alternative transport means, and if demand control measures for car usage and through the taxation be effective, the number of vehicles will increase at a diminishing growth curve. In this case, approximately 3.4 million vehicles, except motorcycles, will be registered in 2006, and 4.1 million in 2011.

The difference between the two cases is as large as about 2 million in 2011. Case 1 might be the most-likely case under no policy intervention, but it will make more difficult to release the road traffic congestion. On the contrary, should Case B be materialized, the traffic burden on roads would be released. For the planning framework of the BEIP, Case 2 is applied with coherence with the proposed transport planning concept.

Meanwhile, the numbers of motorcycles are assumed to be 2.36 million in 2006 and 2.73 million in 2011. The growth rate is thought to be gradually decreasing in the future.

Table 8.4 Planning Framework for Future Development in BMA

	1995	2001	2006	2011	Increase 1995-2011	Avg. Growth Rate 1995-2011 (% p.a.)
Socioeconomic						
Population ('000)	**8,126**	9,044	9,761	**10,496**	2,370	1.6
No. of Households ('000)	**2,037**	2,316	2,578	**2,870**	833	2.2
Household Size	**3.99**	3.91	3.79	**3.66**	-	-
No. of Jobs ('000)	**4,338**	4,757	5,222	**5,681**	1,265	1.7
GPP-BMA (Bil. Baht at 1988 const. Price)	**1,149**	1,823	2,557	**3,422**	2,2 73	7.1
Per Capita Income -BMA ('000 Baht at 1988 const. Price)	**141.4**	201.6	261.2	**326.0**	184.9	5.4
Average Monthly Household Income-BMA (Baht/month at 1995 Price)	**21,032**	25,128	30,021	**33,802**	12,770	3.0
Urbanization						
Urbanized Land Area (Km2)	**541**	606	719	**884**	343	3.1
Urbanization Ratio (% as of BMA total area)	**34.3**	38.4	45.6	**56.1**	-	-
Population Density (prs/ha)	**150**	149	136	**119**	-	-
Motorization						
No. of Vehicles Registered ('000 in BMA)	**1,911**	2,773	3,406	**4,065**	2,154	4.8
No. of Motorcycles Registered ('000 in BMA)	**1,335**	1,936	2,355	**2,730**	1,395	4.6
Vehicle Ownership per Households in BMA (excl. Motorcycle)	**0.94**	1.20	1.32	**1.42**	-	-

Source: The JICA-BEIP Study Team

8.5 Impacts on Environmental Pollutant Loads

The population growth and economic development will eventually bring out significant impacts on the urban environment and bear massive demands for public services and investments. In order to identify the magnitude of the environmental loads of BMA as a whole in the future, the demands for solid waste, water and waste water, which depend directly on the population and economy, were projected. The summary is tabulated in Table 8.5. The detailed arguments on these aspects are made in the respective sector study in Chapters 3 through 8 of Volume 3.

(1) Solid Waste Generation

Per Capita Generation

Detailed data for solid generation is not available, but the statistical records of amounts of collected solid waste are available. Nonetheless, based on an assumption of the service coverage of collection of 75%, a total of about 8,800 ton/day is assumed to be generated in BMA as a whole at present in 1995. The per capita generation amount, therefore, can be computed at 1,083 g/day.

Meanwhile, looking into the time series data of collection amounts, the amounts are growing at 7-8% p.a. and a simple regression function can be derived from the data. Using the same propensity of the regression model, the generation amounts can be estimated in the future, and eventually the annual changes in per capita amount can also be projected. This analysis yields a theoretical scenario that per capita generation amount will grow at 2.2 % p.a. and as the result the per capita generation in 2011 will be 1,540 g/day, or about 1.5 times as large as that at present.

As a planning issue, however, this upward trend of solid waste generation should be controlled with extending an aggressive campaign for "Reduction of Solid Waste" focusing particularly on enterprises. A great effect can be expected on enterprises rather than residents. Then, it was targeted that the per capita generation amount shall be reduced by 15% of the theoretical amount, and stay at the level of 1,308 g/day in 2011.

Total Amount of Solid Waste Generation

A simple method was tentatively applied to project the total amount of solid waste generation in BMA, which is the product of multiplying the population by the per capita generation. A total of about 13,700 ton/day will be generated as the demand for disposal in 2011. In 2006, it will account for 12,300 ton/day with an increase of 3,500 ton/day during next one decade.

(2) Water Demand

Per Capita Water Demand

It is normally understood that the per capita water demand tends to increase along with upgrading of people's quality of living, however, the level of per capita water consumption of Bangkok people, which is projected to be 480 lt./day in 1995, is deemed to be at a saturated level. By promoting an active campaign for "Save Water", and foreseeing a more water-saving economy of Bangkok, the amount will be able to decrease. Based on this perspective, it was assumed to be 440 lt./day as a target in 2011.

Total Water Demand

At present, as of 1995, the total water demand in BMA is projected at approximately 3.9 million cubic meter per day (MCD). The future water demands were projected,

multiplying the per capita water demand by the population, at 4.43 MCD in 2006 and 4.62 MCD in 2011. The additional demand up to 2006 from now will be 0.53 MCD.

(3) Sewage Amount To Be Treated

The potential amount of sewage to be treated is basically identical to the amount of water supply. However, because of some technical and engineering reasons, it should be computed by multiplying an empirical coefficient of reduction. As the result, the total amounts will be 4.25 MCD in 2006 and 4.43 MCD in 2011.

Table 8.5 Tentative Projection of Demands for Solid Waste, Water and Sewage

	1990	1991	1993	1995	2001	2006	2011
Soild Waste Generation							
Per Capita Generation: Planned (g/d)	-	-	-	1,083	1,191	1,257	1,308
Total Generation (ton/day)	6,847	7,211	7,978	8,800	10,774	12,306	13,730
Per Capita Generation: Regressed (g/d)	940	969	1026	1,083	1,254	1,396	1,539
Reduction Target				0.0%	5.0%	10.0%	15.0%
WATER DEMAND							
Per Capia Demand (LPD)	-	-	-	480	465	452	440
Total Demand (MCD)	-	-	-	3.90	4.20	4.43	4.62
WASTE WATER							
Potential Sewege Amount (MCD)	-	-	-	3.74	4.03	4.25	4.43

Source: the JICA-BEIP Study

Box: Incidence of Environmental Problems along with Economic Growth

Environmental Indicator at Different Country Income Level

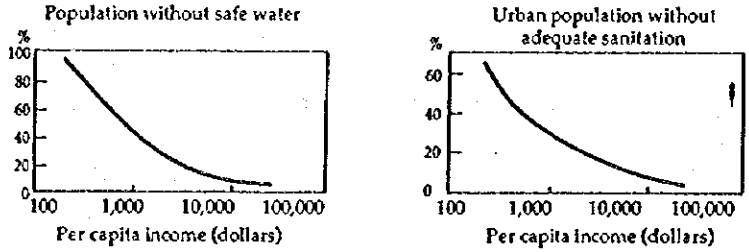
The World Bank Report analyzed the relation between economic activities and environmental problems. Three patterns emerged as follows:

-Pattern 1: Some problems may improve with income growth (water, sanitation)

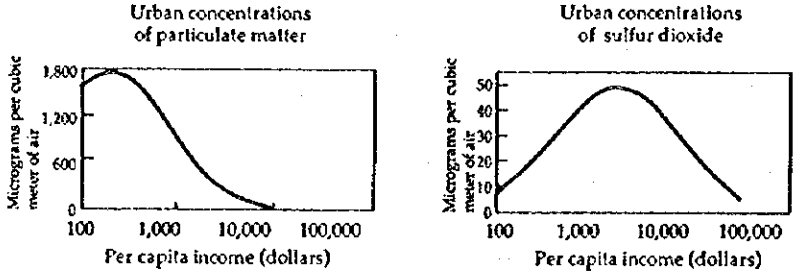
-Pattern 2: Some problems may worsen but eventually improve with economic growth (PM, SOx)

-Pattern 3: Some problems may continuously worsen with income growth (waste, CO2)

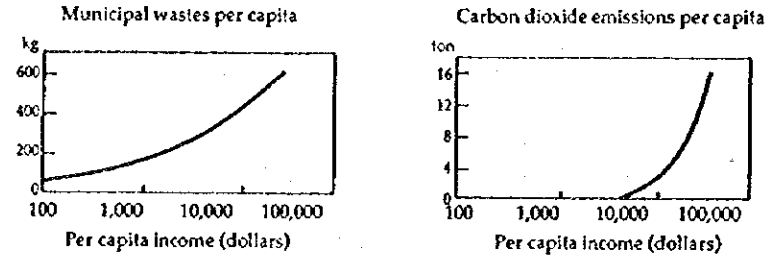
Pattern 1: Increased income provides the resources for public services.



Pattern 2: Some problems improve when country introduces right policies to ensure the input of the additional resources to environmental improvement.



Pattern 3: Some problems worsen as income increases.



Note: Estimates are based on cross-country regression analysis of data from the 1980s.
a. Emissions are from fossil fuels.
Sources: Shafik and Bandyopadhyay, background paper, World Bank data.

Source: World Development Report 1992

CHAPTER 9: A VISION OF SPATIAL FRAMEWORK

9.1 A Regional Spatial Framework

(1) A General View

It is a long-standing issue how to release the excessive concentration of Bangkok Metropolis. Since diseconomies of scale/agglomeration have merged in several forms of traffic congestion and environmental deterioration since one decade ago, any policy paper and/or any plan have addressed the necessity of "decentralization of urban economies" for the substantial solution of this problem. A urban structure reform of Bangkok Metropolis, therefore, has broadly been recognized among relevant authorities. People know that "now" is no longer the time to think, but the time to put into action.

Planning directions of the environmental improvement in Bangkok are eventually derived from this argument, simply because the environmental problems in Bangkok are attributed mostly to the congestion in association with inadequate urban land use and a shortage in infrastructures to support the huge economic agglomeration.

(2) A General Spatial Framework in the Extended BMR depicted by NESDB

The key word is "decentralization", "re-allocation" or "re-distribution" of economic resources over the area. The spatial framework for this argument is not limited to BMR, but a wider extent encompassing vast areas within a 200 km radius from the center of Bangkok, which is recognized as an extent to integrate potential economic activities and resources influenced by the Bangkok economy.

The Thai Government has long pursued the decentralization policy, fostering several regional growth poles other than Bangkok in the spatial framework with a 100-200 Km radius from the center of Bangkok. The first comprehensive blueprint titled the Chao Phraya Multipolis Structure Plan was studied by NESDB in 1994. This plan envisaged a macro-spatial structure to foster three regional sub-government centers in the eastern, western and northern wings centered on Bangkok.

Recently, NESDB has depicted the regional spatial framework for extended Bangkok Region for the 8th National Plan. This follows the same basic concepts raised by the Chao Phraya Multipolis Structure Plan, as shown in Fig. 9.1.

In this context, high priority development is proposed to be the Airtran Corridor (Bangkok-Chachoengsao) to accommodate 940,000 additional population (by 2010) and economic growth to be driven by the SBIA. This corridor includes development of three new centers:

- **Lat Krabang Center** (with a target population of 180,000) for knowledge activities requiring close access to the SBIA;
- **NHA New Town** (with a target population of 250,000) for housing for direct and indirect aviation-related workers of the SBIA; and
- **Chachoengsao West Complex** (with a target population of 400,000) for a regional center with manufacturing headquarters and a R & D center.

Equally, the other two growth centers are highlighted as high priority development:

- the ESB Core, centered on Chonburi; and
- the Greater Suraburi Industrial Core (GSIC).

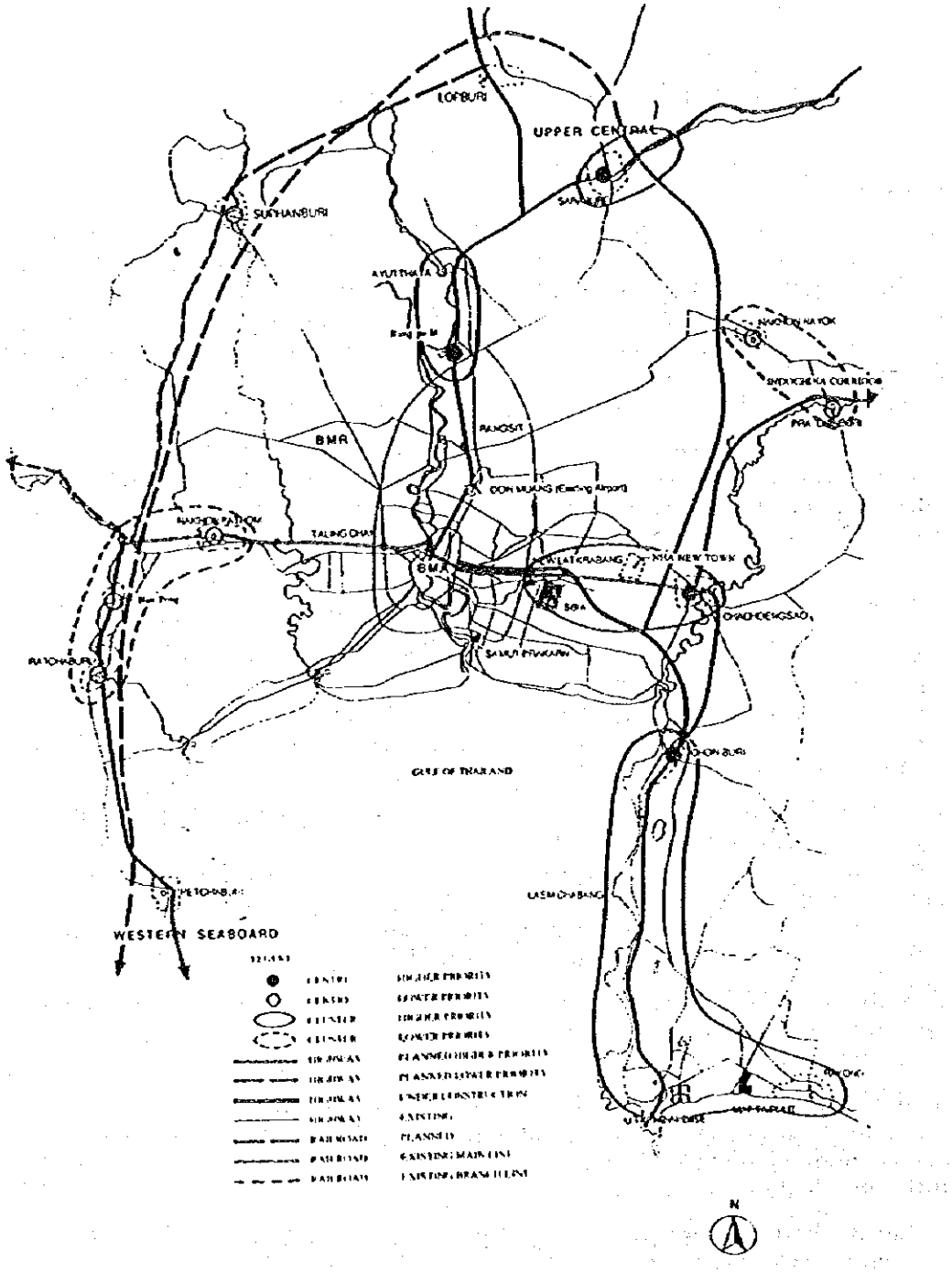


Fig. 9.1 A General Spatial Framework of the Extended BMR (NESDB)

(3) Regional Spatial Structure for the Greater Bangkok Metropolis (Proposed)

Based on the above spatial framework proposed by NESDB and long-standing planning discussions on decentralization schemes, the BEIP team envisages a regional spatial structure for the Greater Bangkok Metropolis as shown in Fig. 9.2.

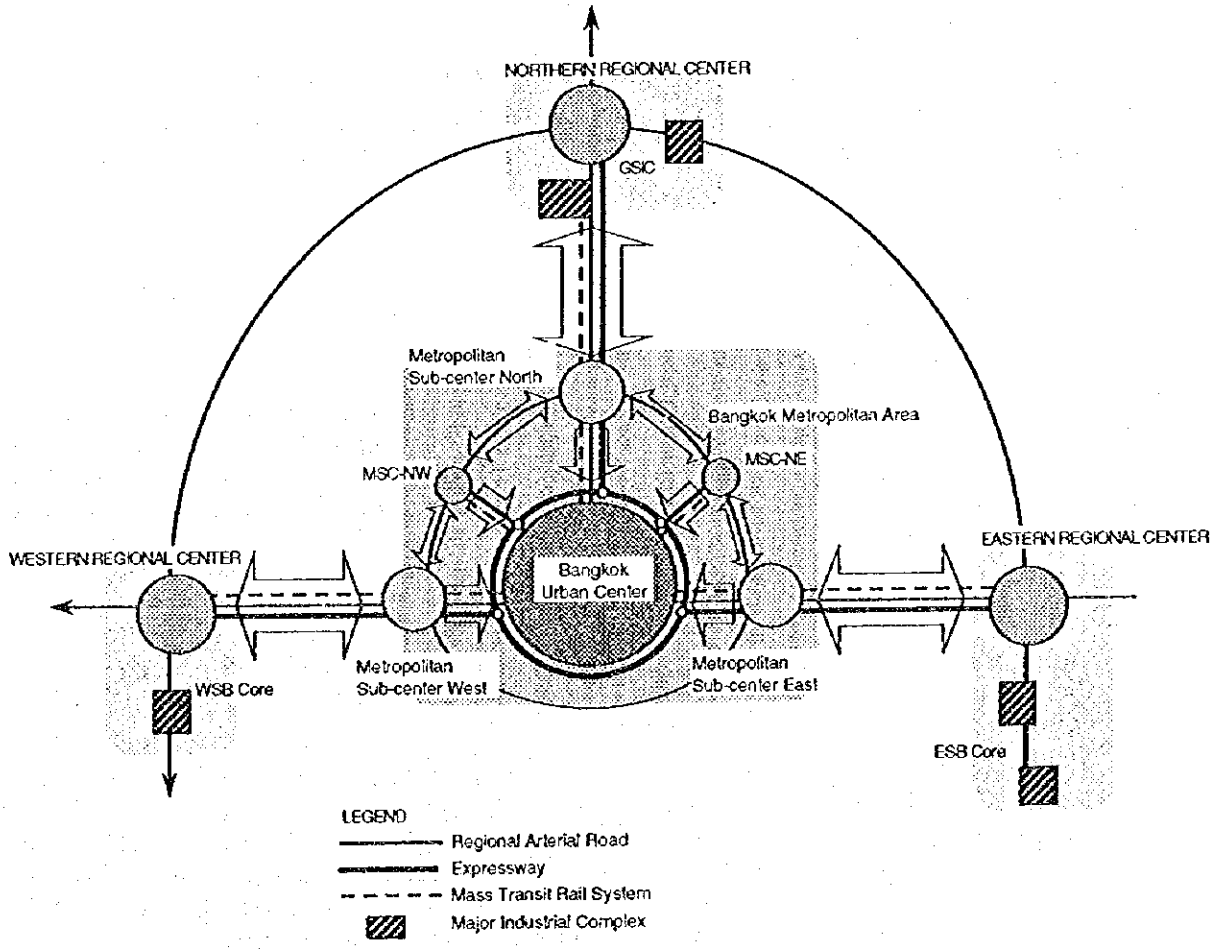


Fig. 9.2 A Conceptual Regional Structure for the Greater Bangkok Metropolis

9.2 Existing Physical Plans for Decentralization Policy

In the line with the decentralization policy, new urban settlement centers are being planned and/or conceptually depicted by different organizations. The basic planning concepts underlying all the plans are similar but locations, spatial settings and functions are different, depending on organizations concerned without planning coordination.

Since all the schemes have been neither fixed nor committed yet, the BEIP team cannot assess all the ideas/plans for the basic spatial framework of the planning. However, the BEP team strongly endorse the plan to shift the Bangkok urban structure towards a multi-polar system, planning coordination among and collective effort with both the central and local governments are absolutely needed immediately, otherwise potential economic resources of both the public and private sectors could not be integrated towards an appropriate direction, thereby resulting in bearing huge economic losses.

The following are a summary review of these existing plans/ideas.

(1) Metropolitan Subcenters by the Bangkok Plan (MIT/EC Team, BMA)

Along the Outer Ring Road, a total of eleven (11) subcenters are planned, out of which five (5) subcenters are located within the BMA jurisdiction, as shown in Fig. 9.3, namely,:

- New Lat Krabang;
- Expanded Min Buri;
- New Lam Lukka;
- New Taling Chan; and
- New Bang Khun Thian Centers.

The Report says, "Metropolitan subcenters will absorb and structure some of the future development that will occur in suburban areas with the building of new infrastructure such as Outer Ring Road and the Second Bangkok International Airport. Subcenters should be located where radial mass transit lines or commuter railways will intersect with the circumferential outer ring road".

The BEIP team views this proposal from the following standpoints:

1) The three (3) suburban centers proposed in the eastern part of BMA are all located within the "Suburban Development Control Area" which has been proposed from the standpoint of environmental protection in the same plan. This seems contradictory to each other in planning concepts.

2) The concept of subcenters would function as suburban terminals of the on-going/planned mass transit systems. This concept must be attractive enough for the private sector to encourage its investments on land development. Therefore, because of this, a thoughtful implementation scenario concomitant with the institutional system for growth management needs to be prepared. Otherwise, this concept would create another congestion problems in suburban areas.

3) The suburban center concept should be integrated with a restructuring and relocation scheme in the inner city in planning, taking into account the implementation. Otherwise, the public meanings of suburban center projects would be half lost. This integrated concept is not addressed in the Bangkok Plan.

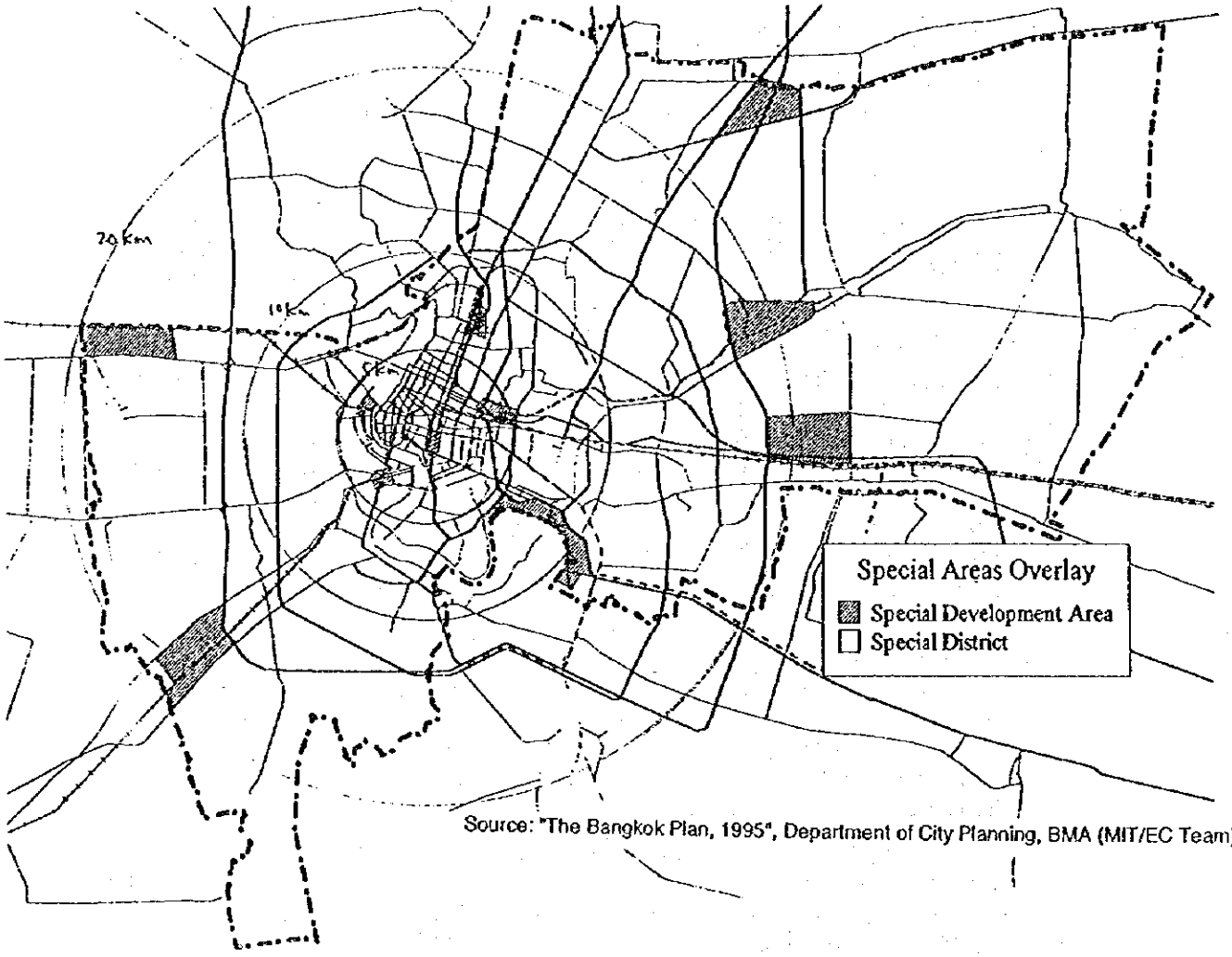
4) Outer Ring Road will function as a key trunk road supporting industrial and commercial activities in not only Bangkok but also BMR. This arterial road is expected to make inter-regional cargo traffic flows more smooth and efficient without passing through the inner city. To this end, large-scale commercial development alongside or facing the road should be restrained in order to avoid congestion at/around intersections caused by mixed traffic with short-distance

trips and long-whole industrial trips. Therefore, subcenter development adjacent to intersections with other arterial roads should be avoided.

5) The BEIP team holds the following impressions on the proposed subcenters throughout the site observations:

- **New Lat Krabang**: Most potential areas for new settlement centers to accommodate not only new housing, industries, commercial and services development but also would-be-relocated urban functions such as high education facilities, public services and transport-related business. However, the most thoughtful considerations should be paid to environmental preservation due to its environmentally sensitiveness.
- **Expanded Min Buri**: More intensive efforts on development management and infrastructure should be made to facilitate and strengthen the existing center of Min Buri District which is already well-functioning as a suburban center, rather than dispersing the effort on another new suburban center development.
- **New Lam Lukka**: Looking into changes in land use around this area, predominant uses are limited to transport- and goods distribution-related industries such as construction materials stock yards, warehouses, energy distribution center, forwarding business, and some number of sub-division projects, so on. Although there is no plan of any mass transit system serving this corridor, this area is endowed with further potentials to locate collectively these functions in the future, as an "inter-regional good distribution center" with inter-relations with the northern and eastern regions' economies. The location and the scale should be carefully deliberated in consideration of the water-related environmental conditions.
- **New Taling Chan**: In general, this corridor seems to be rather backward in development and still waiting for a new momentum of investment to land development than the eastern part of BMA. This area is susceptible to flood, therefore, it might be a good model for the public sector-initiated development in full considerations of environmental aspects to guide the private sector's activities into a proper way.
- **New Bang Khun Thian**: In terms of expected functions of the subcenter, this area seems to have a great potential to accommodate transport-related industries same as **Lam Lukka** in the north-eastern part of BMA. Given the improvement of the existing railway as a commuter service line with extension of the Hopewell-SRT System (Red Line) in association with the extension of the MRTA System (Blue Line), this corridor will be undoubtedly a new focal area for urbanization in the long-term. Since the ribbon development has progressed in this corridor, the problem is how to realize it.

Fig. 9.3 Subcenters Development Concept Proposed by the Bangkok Plan (Proposed by MIT/EC Team)



Source: "The Bangkok Plan, 1995", Department of City Planning, BMA (MIT/EC Team)

(2) New Town Development (NHA)

In compliance with housing supplies for low- and middle-income households' demands, NHA has its own plans/programs for housing supply in various forms such as slum improvement; public housing provision, urban renewal project and new town projects. The new town project is rather newly conceptualized.

The Ban Plee Newtown in Samut Prakran Province is the first project being on-going. The Ban Plee Newtown covering a total area of 715 ha, of which 267 ha was completed in 1988 for the first phase, and the remaining 448 ha, being constructed for the second phase toward the completion in 1999. This newtown is planned to grow up as a self-contained community with a 130,000 population, providing job-opportunities in industrial and commercial facilities. Environmental measures for flood protection, drainage system, road network system and public utilities and open space are well taken into account in its plan and design as a publicly initiated-large scale project.

NHA is seeking potential and suitable areas in/outside BMA for several newtown projects each of which has a land area of more than 100 ha, Five (5) areas, in each which a few newtwon projects are to be initiated during the 8th Plan period, have been designated as shown in Fig. 9.4.

It is noted that NHA is considering two (2) types of newtown: semi-self contained and self-contained. The newtowns in the major three corridors in the eastern, western and northern bounds are planned to be self-contained, and the other two locating in-between the three corridors, semi-self contained. Among them, the highest priority is given to the Chachoengsao area.

(3) New City Projects Proposed by DTCP

DTCP recently presented a concept paper titled "City Planning as A Method to Solve Traffic Problem" (September 1996), demonstrating DTCP's strategies for new city projects (or satellite towns) which would be developed within a radius of not more than 100 km from Bangkok or reachable within a traveling time of 1 hour. The satellite towns will accommodate 100,000 to 150,000 population to be moved from Bangkok and the vicinities with at least 100 sq. km.

In the line with this concept, DTCP focuses on three sites as follows:

- **Phra Intaraja New City**: locating in Phra Nakhon Si Ayuthaya Province, the north of Bangkok, and expected to function as a hub to coordinate the economic expansions of Bangkok Metropolis with North and Northwest Regions with a special function of "communication center" as well as offices, business and residences.
- **Lad Loumkaeo New City**: locating in Pathum Thani Province, the west of Bangkok Metropolis, at the position to link with Western and Southern Regions;, with emphasis on accommodating governmental agencies, universities and institutions and pollution-free facilities.
- **Suwintawong New City**: locating in Chachoengsao Province, the east of Bangkok Metropolis, to accommodate the economic expansion concerted with air and sea transportation as an industrial city with commerce and technology combined.

The locations of the three focal areas are as shown in the same figure of Fig. 9.4. DTCP discusses measures to put the plans into reality, and it proposes to apply "**Land Readjustment System** [1]" to this end.

This satellite town concept seems related partially to the MIT proposed subcenters concept on the one hand, and follows partially the MRSP concept as reviewed in the

[1] The Land Readjustment Act has currently been passed by Ministry of Interia on September 11, 1995, and the approval from the Cabinet is being sought.

preceding section on the other hand. That is, **Phra Intaraja and Lad Loumkaeo** are identical to the MIT proposed subcenters along the Outer Ring Road, and **Suwintawong** is not. However, it seems that the DTCP plan itself is unique with little relevance to those plans.

DTCP, in addition to the above three centers, is studying other three satellite towns just outside BMA,: Bang Bua Thong, Samutsakhon and Bang Plee.

(4) Railway-oriented Urban Development Proposed by the JICA Study

The JICA Study titled "An Improvement Plan for Railway Transport In and Around the Bangkok Metropolis in Consideration of Urban Development (IPRT)" was recently submitted to NESDB and SRT, in August 1995. IPRT proposed a unique and rational urban development concept, highlighting the urban development stimulated by railway and/or mass transit system in the greater metropolitan area with a 200 km radius from the center of Bangkok as shown in Fig. 9.5. This concept is basically in the line with the NESBD policy that the major three corridors should be further encouraged for decentralization of Bangkok, but more unique ideas for urban development have been included in the plan. These are:

- Four Sub-urban Centers in Railway Corridors in Chachoengsao, Nakhon Pathom, Ayuthaya and Samut Sakhon
- Rail-oriented Urban Development to accommodate 1.7 million population in 2010
- Area-wise Urban Development in Railway Corridors with a variety of urban development cum major railway stations

In the Eastern Rail Corridor, there are two large scale development: **Aero-based City** to develop housing and commercial, business establishments around the Second Bangkok International Airport, which is similar to the DTCP's plan of Suwintawong New City; and **Eastern Bangkok Park City** to designate new residential area with high quality housing, allowing residents to commute conveniently to/from both Bangkok and ESB.

In the northern corridor, **Techonodemic City** was proposed, where housing and business establishments, colleges/universities and R & D laboratories are to be encouraged to locate.

In the western side, proposed are **Western Bangkok Garden City** as intensive quality housing area and **Pier City** including the existing Maha Chai urban areas in front of the Gulf of Thailand.

For materialization of this concept, IPRT recommends the improvement of the Eastern Line of SRT for a modern commuter line, including construction of six (6) new stations and construction of a new airport access line (a 7.0 km feeder line from Lat Krabang Station) in association with the improvement of the inter-city line between Bangkok and Map Ta Phut through Chachoengsao. This program is estimated to cost about 13 billion Bahts [2], comprised of 1) double tracking; 2) electrification; 3) modernization signaling; 4) level-crossing improvement; 5) improvement of stations and 6) procurement of rolling stock and electric cars.

In fact it has been recognized that a massive volume of traffic demands generated from the Bangkok economic activities can no longer be supported only by roads, and that a drastically structural change in urbanization based on railway/mass transit systems is critically required. The BEIP Team strongly endorses these proposals presented in IPRT.

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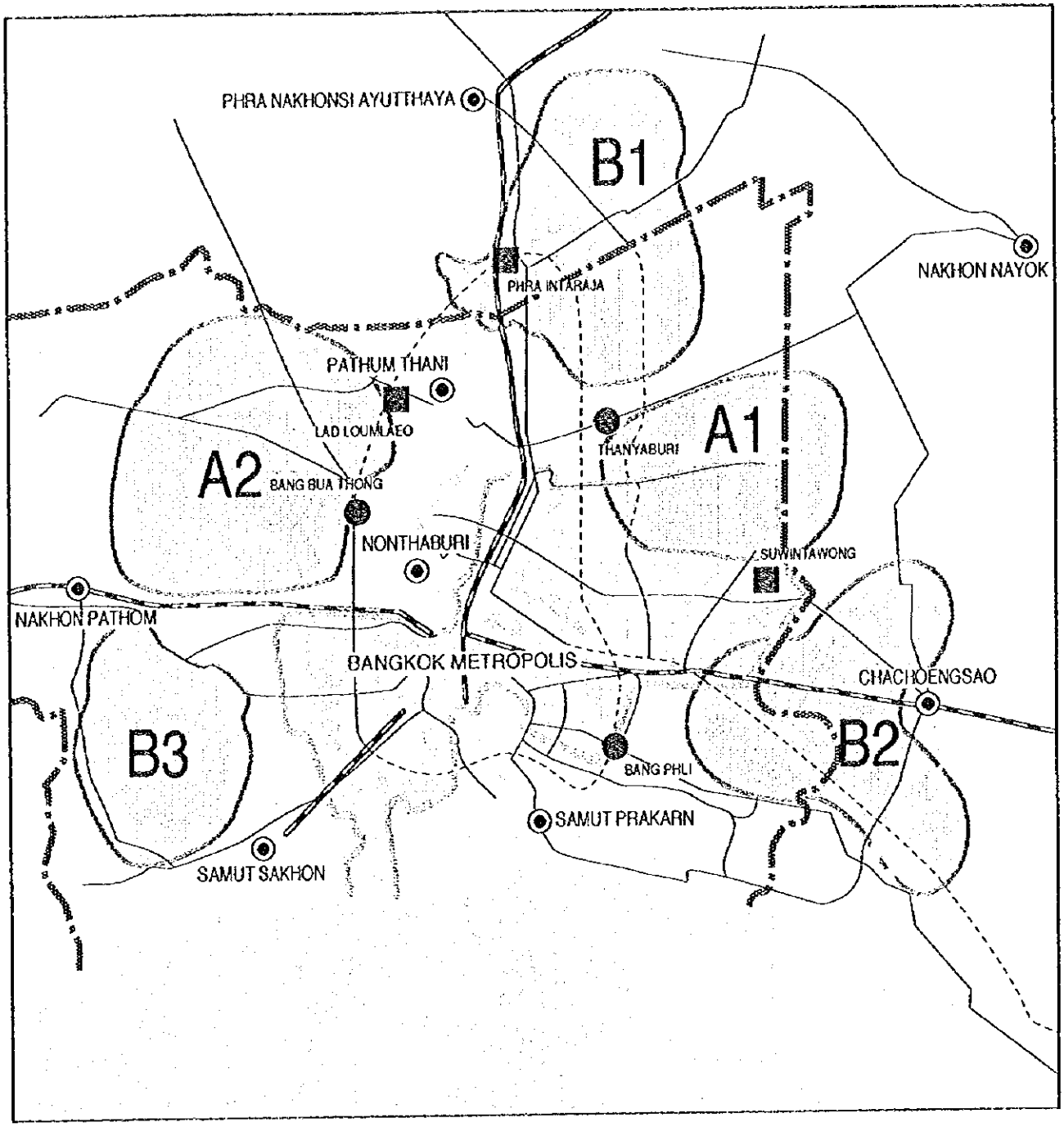
[2] The evaluation of this huge scale investment project concludes that the project is feasible from the economic point of view, or EIRR is computed at 16.3%, and that the project will be financially viable, or FIRR is over 7%, if the external free funds may cover 60 % of the initial investment.



LEGEND :

DTCP Proposal New Cities

- Most recently proposed new city development
- Previously proposed and / or under-considering location of satellite town / new city development

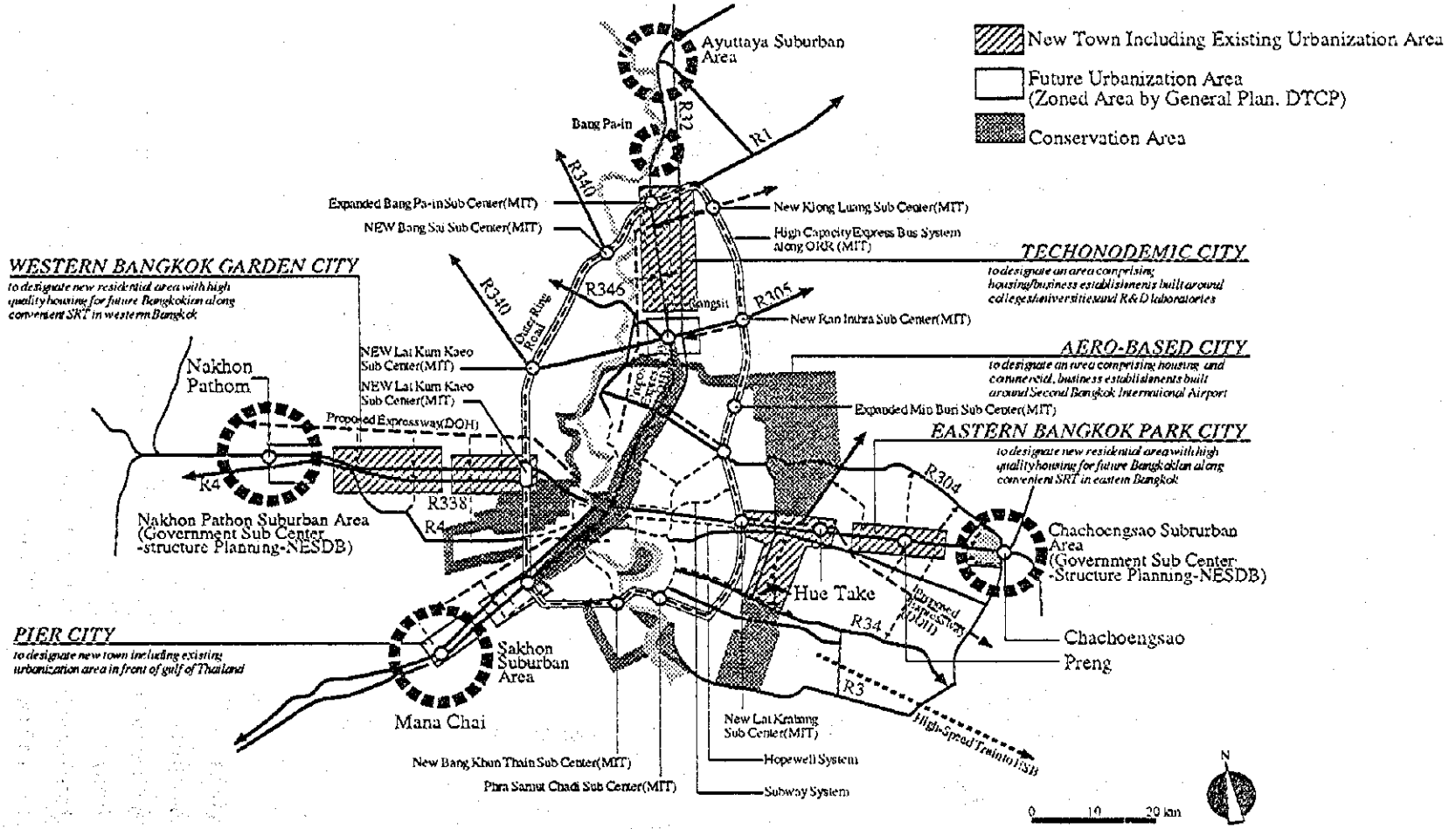
NHA Proposal New Towns

Area "A" : Suitable Location For Semi-self Contained New Town & Self-contained New Towns

Area "B" : Suitable Location for self-contained New Town

Source : "City Planning As A Method to Solve Traffic Problem, 1995", Department of City & Country Planning (DTCP), and National Housing Authority (NHA)

Fig. 9.4 Proposed New Cities and New Towns by NHA and DTCP



Source: "An Improvement Plan for Railway Transport in and Around the Bangkok Metropolis in Consideration of Urban Development, 1995". NESDB-SRT (JICA STUDY)

Fig. 9.5 A Framework Plan for Rail-oriented Urban Restructuring in Bangkok

9.3 Restructuring of Spatial Structure of the Bangkok Metropolis

Based on the review of all the existing plans and discussions, the BEIP team proposes a scheme of restructuring the spatial structure of the Bangkok Metropolis towards a sustainable urban growth.

(1) A Conceptual Spatial Structure of BMA

With the one-center urbanization system, the mega-urban agglomeration with more than 10 million population can no longer efficiently work as a functional unit. Urban restructuring to shift the one-center system to a multi-polar system gradually becomes a vital issue as diseconomies are apparently emerging.

A conceptual structure with a multi-polar system is proposed, instead of the current one-center system, as conceptually illustrated on Fig. 9.6. The following considerations are underlying this proposal:

As the life-line of the Bangkok economy, an efficient goods distribution structure needs to be developed, while facilitating inter-regional economic relations. Cargo traffic flows should be functionally treated with less impacts on passenger traffic. For this purpose, truck terminals and distribution facilities needs to be developed in urbanized fringe areas where are suitable for inter-connection with the inner distribution and the regional linkages. Those are to be located in, at least, three locations along the eastern, western and northern corridors;

Road traffic concentration should be dispersed in association with keeping the job-housing balance outside the central area. For this purpose, as proved by the simulation analyses in Chapter 5, creation of new job opportunities needs to be placed in newly developed subcenter areas.

(2) Urban Regeneration:

The central areas, although they are endowed with a relatively high road density and well-infrastructures, have nowadays faced a difficulty in that there exist many buildings and land uses which are no longer economically functional because they are going out of date, or facing diseconomies from traffic congestion. These are awaiting for regeneration, redevelopment and/or renewal.

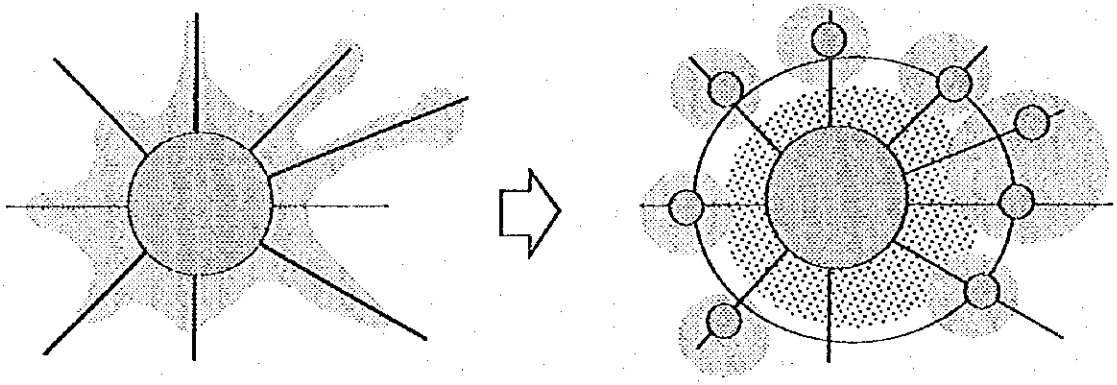
(3) Sub-urbanization:

Urban sprawl has rapidly been proceeding along several major corridors in various forms: individual, shop-housing types, sub-division development, so on without an adequate landuse management system. Eventually, provision of infrastructures and public services cannot catch up with the demands. A more deliberated manner is necessary for orderly sub-urbanization.

(4) Mass-Rapid Transit-Driven Urbanization

As widely recognized, the most effective way to facilitate the urban re-structuring towards a multi-polar system, instead of the present one-center system, is to deliberately utilize the economic and urban functions of mass-rapid transit systems (MRTs).

Areas, easily accessible to major stations of the planned MRTs, may be of newly high valued land, thereby enlarging economic potentials for housing, light industrial commercial and business development. Since stations of MRTs are significant traffic generators, such mass-transit driven urbanization is effective for management of traffic demands. Inter-modal transfer systems, including bus services as feeder transportation, should be improved.



Urban Sprawl without Growth Management

Multi-polar Metropolitan Structure

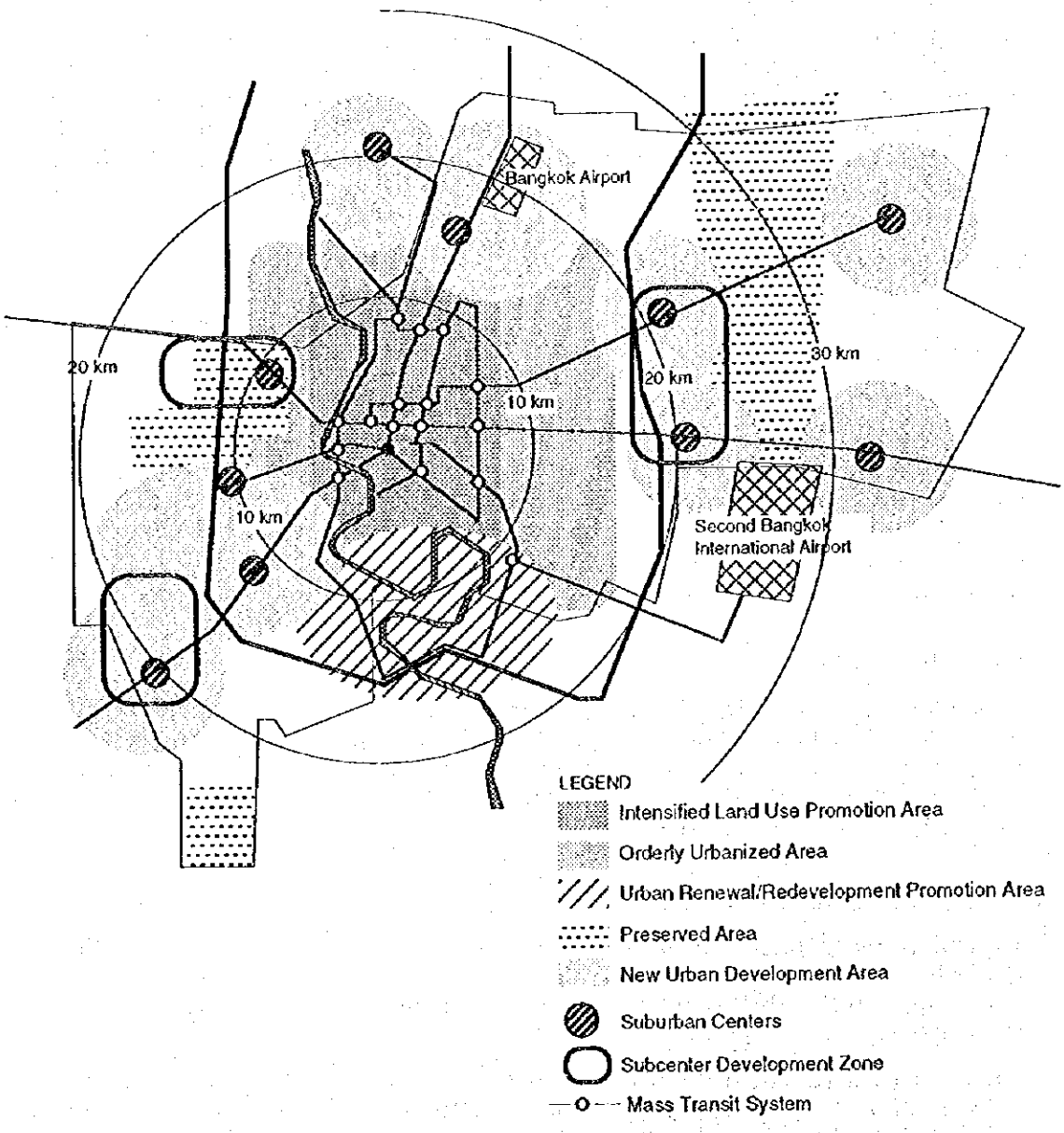


Fig. 9.6 A Concept of BMA Restructuring Spatial Framework (Proposed)

9.4 Planning Strategies for Metropolitan Subcenter Development

As a tool to materialize the long-standing decentralization policy, the BEIP team strongly endorses the metropolitan subcenter development to release environmental loads of the Bangkok Metropolis. However, the proposal by the Team stands on a bit different planning concept from the previously proposed ones as viewed in the preceding section.

Important is the planning concept of "Subcenter Development" that does not necessarily stand for only development of a core of "Business Center", but includes the area-wise urban development centered on the core. Accordingly, it may be rather called "Subcenter Zone Development".

(1) Rationales of Subcenter Zone Development

Sub-center development should be facilitated, because of three reasons:

1) Excessive traffic concentration into the central business areas is causing a great economic loss on the Bangkok Economy as a whole, therefore dispersal of traffic demands should be encouraged. As proved in the simulation analyses in Chapter 5, the policy is significantly effective to mitigate road traffic congestion.

2) The 10 million urban agglomeration can no longer be efficiently formed by the one-center system in view of the limits of spatial capacity and provision of necessary infrastructures while maintaining a sound urban environmental system.

3) Development of subcenters shall provide the space to meet new land demands for urban service facilities to be additionally developed, could-be-relocated and/or moved facilities/activities from the central areas where a pressure for regeneration is emerging for encouraging more efficient urban land use.

4) As a model of publicly-initiated and infrastructure-led suburban development, an institutional system for the implementation of orderly area-wise development shall be explored through the subcenter development.

(2) Urban Planning Requirements on Subcenter Zone Development

As a model of environmentally sound suburban development, the plan should first take into account a "Balance of Water and Land", in other words, land development with sufficient water management systems.

In addition to this, the subcenter zone development shall be planned with the following five (5) functions:

1) To provide a wide range of job-places (for low to high income groups)

2) To accommodate a wide range of business and urban functions required for the Bangkok economy toward the new generation such as:

- Information-based and related industries, high educational facilities and R&D functions (for a knowledge center);
- Warehouses, small- and medium scale light industries, goods distribution and cargo transport-related facilities which are to be relocated or newly established;
- Resort for "New Business Incubator";
- Support or related facilities to adjacent large-scale projects (such as SBIA); and
- Government offices/service facilities to be relocated (preferable as a trigger).

3) To contribute to substantial or partial solutions of current urban environmental problems in Bangkok such as difficulties in land acquisition for :

- Solid waste management system; and

- Flood prevention, environmental green and recreation;
- To provide a wide range of urban services for its surrounding communities to form a self-sufficient sub-economic zone centered on the sub-center function.

4) To become an intermodal transport terminal with highly served public transport systems.

(3) Criteria for Selection of Suitable Location for Subcenter Zone Development

Development of the subcenter zones should be located in areas with the following conditions:

1) Less natural constraints of the environment, i.e., areas to be preserved for flood control should be avoided;
2) Along the planned mass-transit corridor;
3) Within 40-60 min. time-distance by mass-transit system to/from the existing Bangkok urban center;
4) High accessibility and easy mobility by road transport to/from the surrounding communities (existing and future) as well as major traffic generators;
5) Comparatively low urbanization ratio (less than 30%, not necessarily vacant land);
6) Presently low service levels of community facilities; and
7) Preferably with public land as much available as possible.

(4) Proposed Three Locations

Analyzing the whole land with the above conditions within the BMA jurisdiction using the GIS technique, the BEIP team identified three suitable areas as shown in Fig. 9.7 (the process of the analysis is discussed in Section 12.3). These are: Minburi/Lat Krabang; Taling Chan; and Bang Khun Thian.

Minburi/Lat Krabang Zone (6,700 ha)

As proposed in the Bangkok Plan and other plans, Lat Krabang is assessed to be a focal area with great urban potentials to be influenced by the new transport facilities such as the Red Line MRT, Bangkok-Chonburi Highway and the Second Bangkok International Airport. And, Minburi is already functioning as a subcenter in the northeastern suburban area attracting many housing subdivision projects. Provided with the extended Orange Line, Minburi will be another focal area for development.

This subcenter zone encompasses the considerably vast area combining these two potential centers between Outer Ring Road and the King's Dike.

Taling Chan Zone (4,800 ha)

Having the existing SRT Southern Line, the extended Red Line MRT and Outer Ring Road, Taling Chan area will undoubtedly be a further significant area for urban land development in the Thonburi side. Since the areas are environmentally sensitive against floods, without a public-initiated orderly development scheme in consideration of environmental preservation measures, this area would bear another environmental problems. The zone extends towards East-West along the Southern Line.

Bang Khun Thian Zone (3,899 ha)

As a gateway to the southern Thai economy, a number of industries and transport service facilities are now located in Bang Khun Tian area. Having the extended Red Line MRT and Outer Ring Road, this area will have another potential to attract a

Fig. 9.7

Proposed Locations of Development of Three Subcenter Zones

Legend

- Current Buildup Area
- Park
- Urbanized Area in 2001
- Urbanized Area in 2006
- Urbanized Area in 2011
- Existing Road (Class 1, 2)
- Existing Road (Class 3)
- Existing Expressway
- MRT Systems
- MRT Systems Expansion
- Expressway in 2000
- Improvement of Existing Road (DOH)
- New Road in 2000 (DOH)
- Improvement of Existing Road (BMA)
- New Road in 2000 (BMA)
- Improvement of Existing Road (PWD)
- New Road in 2000 (PWD)
- BMA Boundary
- District Boundary
- Chaopraya River

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KILOMETERS

THE STUDY
ON
URBAN ENVIRONMENTAL IMPROVEMENT PROGRAM
IN
BANGKOK METROPOLITAN AREA (BEIP)

BANGKOK METROPOLITAN ADMINISTRATION(BMA)
THE GOVERNMENT OF THE KINGDOM OF THAILAND

JICA JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)

variety if urban functions as a suitable place for would-be-relocated facilities. This area will be a core of further development in the Tonburi side.

It is noted that the areas of the above zones are determined as the "Urban Planning Areas" to be developed under the subcenter development policy. These include existing built-up areas where need to be improved as part of the subcenter zones.

(5) A Development Framework of Subcenters

Scale of the Development

Meanwhile, in the longer-term beyond 2011, the Bangkok population is thought to ultimately reach a saturation point of about 12 million, which is regarded as a limit of the carrying capacity of BMA. Therefore, the population will increase by about 4 million from 1995. A question is how to accommodate the increased population. In this regard, two planning concepts were employed as a planning vision:

1) At least, one third of the increased population should be guided to settle in the infrastructure-led urbanized areas;
2) Since the subcenter development is a policy instrument to lead to the re-structuring of the Bangkok Metropolis to lessen the environmental loads, its scale of development needs to be as large as being effective to that policy.

Consequently, three zones are proposed to become urban agglomerations with more or less 500 thousand residents at the ultimate stage:

- Minburi/Lat Krabang Zone: 700,000 residents;
- Taling Chan Zone; and: 500,000 residents; and
- Bang Khun Thian Zone: 400,000 residents.

In practice, these large scale development projects take long time up to the completion, probably 10-20 years, referring to the experiences in cities of advance countries. Even though the projects start with preparing the action plan in a few years, an only 10% progress could be expected. Such a most-likely settlement schedule is projected as shown in Table 9.1 and Fig. 9.8.

Housing-Job Balance

In order to guide the subcenter zone development toward the deliberated direction, the housing and job balance should be kept, in other words, self-sustained subcenters. This must be an essential and critical condition. Therefore, each zone is planned to locate jobs as many as required from the planned population. Of course, it cannot be imagined that all employees working in the subcenters reside in the subcenter zones, but in terms of the job-and-housing balance it should be of being self-sustained for each zone. The Jobs allocation scheme, based on the above perception, is as shown in Table 9.2.

Land Use Framework

The most important requirement in physical planning is to prepare sufficient land areas for open space for greens, parks, drainage and water retention as well as roads and related infrastructures. As a guideline of land use, the BEIP team proposes that at least 15% of the area should be used for road and transport infrastructures, and more or less 20%, for the environmental open space.

Land demands for housing, commercial/business and industrial uses can be derived from the above concept of the job-and-housing balance policy. A framework of land use and urban functions of the three zones is proposed as shown in Table 9.2.

Table 9.1 Population Settlement Schedule of Three Subcenter Zones (Proposed)

(Thousand)

		1995	2001	2006	2011	Long-Term Target
BMA Population		8,126.0	9,044.0	9,761.0	10,496.0	12,000.0
Population in Existing Built Up Area		8,126.0	8,332.7	8,509.0	8,689.0	9,000.0
Population in Future Expanded Built-up Areas			365.8	750.5	1,114.5	1,650.0
Population in Subcenter Zones		284.5	345.5	501.5	692.5	1,350.0
Minburi/Lat Krabang	Existing Population	125.0	125.0	125.0	125.0	125.0
	Future Expanded Built-up Area in Subcenter Zone		7.0	59.5	93.5	93.5
	Newly Developed Subcenter Zone				61.5	481.5
	Total	125.0	132.0	184.5	280.0	700.0
Talong Chan	Existing Population	77.0	77.0	77.0	77.0	77.0
	Future Expanded Built-up Area in Subcenter Zone		18.0	43.0	58.5	58.5
	Newly Developed Subcenter Zone				14.5	114.5
	Total	77.0	95.0	120.0	150.0	250.0
Bang Khun Thian	Existing Population	82.5	82.5	82.5	82.5	82.5
	Future Expanded Built-up Area in Subcenter Zone		36.0	114.5	145.0	145.0
	Newly Developed Subcenter Zone				35.0	172.5
	Total	82.5	118.5	197.0	262.5	400.0

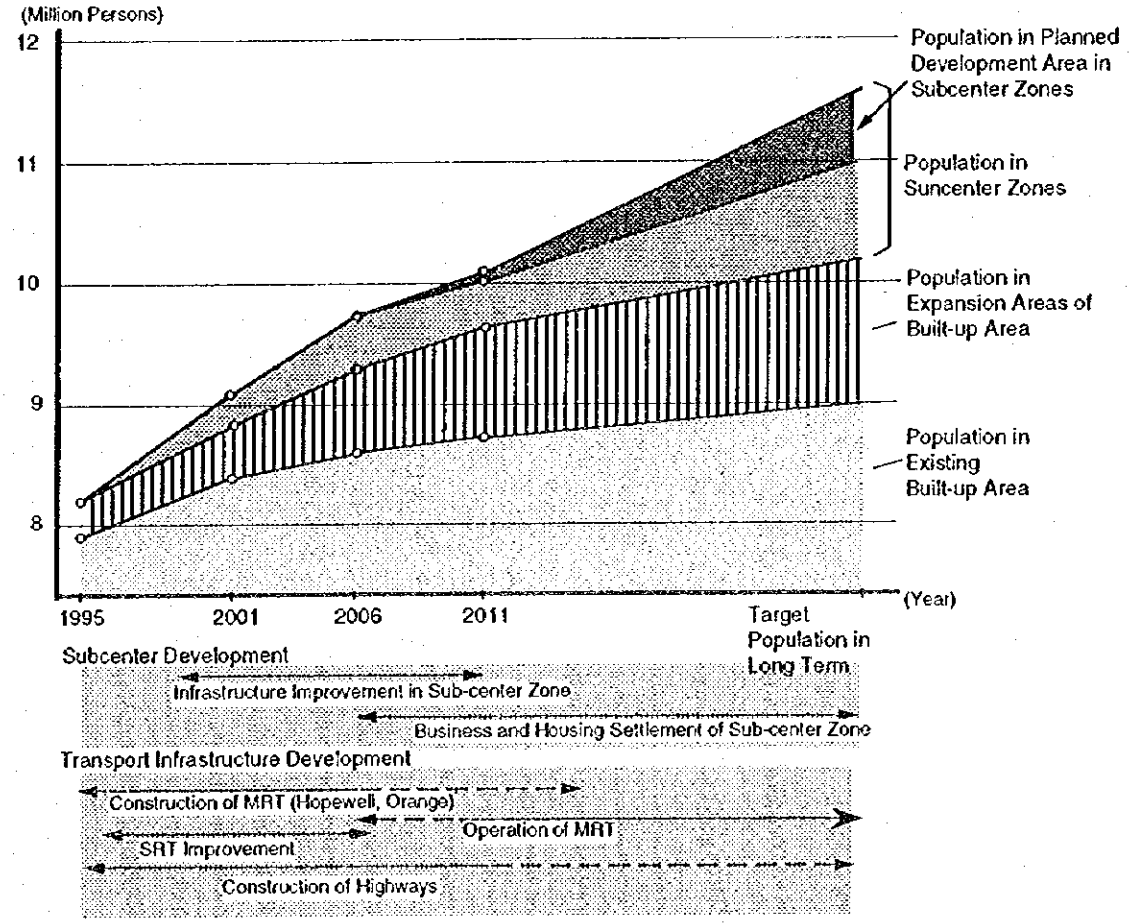

Fig. 9.7 Long-term Future Population Allocation in 2011 and Over

Table 9.2 Development Framework for Three Subcenter Zones Development

	Unit	Minburi/Lat Krabang		Taling Chan		Bang Khun Thian	
Major Subcenter Functions To Be Enhanced		Business, Light Industry, Higher Educational and Government Facilities, R & D and Information, Cargo Distribution, Commercial and Residence		Business, Commercial, Higher Educational and Government Facilities, and Residence		Production and Light Industry, Cargo Distribution, Commercial and Residence	
Target Population	000	700		500		400	
Planned Population in 2011	000	280		150		260	
Target Employment	000	420		300		240	
Planned Employment in 2011	000	84		45		78	
Area of Subcenter Zone	ha	6,700	100%	4,800	100%	3,800	100%
Existing Built-up Area	ha	1,130	17%	700	15%	750	20%
Future Expansion of Built-up Area	ha	850	13%	660	14%	1,480	39%
Planned Development Area	ha	4,720	70%	1,040	22%	1,570	41%
Land Use Composition							
Commercial & Business	ha	350	5%	240	5%	200	5%
Production/Industry	ha	350	5%	100	2%	200	5%
Residential	ha	2,950	44%	2,280	48%	1,900	50%
Public Service Facilities	ha	700	10%	500	10%	300	8%
Parks, Open space and Reserve	ha	1,350	20%	960	20%	630	17%
Transport Facilities	ha	1,000	15%	720	15%	570	15%
Existing Core Local Center		Minburi		-		Bang Khun Thian	
Available Mass Transit System		Red Line (Hopewell),Orange (MRTA),SRT		Red Line (Hopewell),SRT		Red Line (Hopewell),SRT	
Available Major Arterial Roads		Outer Ring Road,		Phet Kasem Road			
Notable Projects and Development in the Surroundings		Second Bangkok International Airport; Lat Krabang Industrial Estates; Truck Terminal; Active Subdivision Development;		Proximity to Existing Urban Center; Availability of large agricultural and open space areas; Active Subdivision development		Active development of factories and warehouses; Active subdivision development; Truck Terminal	

(6) Physical Planning of Subcenter Zone Development

Physical planning work for the subcenter zone development are recommended to be conducted as soon as possible. The existing study titled "Metropolitan Subcenter Planning" (October 1996) conducted by the MIT Consultant Team provides with several significant insights into the projects. In this BEIP Study, several planning concepts are demonstrated in Micro Studies in Chapter 24.

(7) Key Elements for the Implementation

Development of the subcenter zone requires to establish a specially unique system for the implementation, including some institutional arrangement. The following are strongly recommended for actions to the implementation:

1) Government (or the public sector) initiative in planning with well-coordination among relevant planning organizations such as BMA, NESDB, OCMRT, DTCP, NHA, MOSTE and so on;
2) Legal designation of "Subcenter Development Zone" as a policy zone under the Urban Planning Act;
3) Private sector's participation in planning the implementation scheme (the key may be involvement of operators/investors of mass-transit systems);
4) Establishment of a chiefly responsible entity (in a form of public-private JV) for the implementation;
5) Establishment of a land pre-purchase system and a land pooling system by the government sector;
6) Pursuance of alternative land development systems, mobilizing feasible ideas of "Land Readjustment System" and "Land Trust System" proposed by the MIT Consultant Team; and
7) A well-coordination system for development priority of infrastructures among relevant authorities such as BMA, DOH, ETA, MRTA, BMTA and so on.