# CHAPTER 9: HOUSING AND HUMAN SETTLEMENT

## 9.1 General

Bangkok has approximately 5.6 million population with some 1.3 million households in 1993, according to the BMA registration date. However, the actual population is estimated at approximately 8 million in 1995. The number of households has increased at a 4.4% p.a. during the period from 1980 to 1990. The average household size is 3.8 persons/household with a decreasing trend, thus nuclear families seem to be recently increasing.

Bangkok families live in several types of houses such as detached houses, townhouses, apartments and flats, condominiums, row houses, so on. As seen in Table 9.1, 44% of all the families reside in detached houses, and 33%, in either row houses or brick row houses.

Recently, the housing market has been very active, providing with neat townhouses targeting at the middle income families in suburban areas. On the other hand, shanty houses still remain in several areas along Khlongs and the old city.

**Table 9.1 Number of Houses by Type in Bangkok**

| Person | Detached House | Townhouse | Apartment, Flat | Condo-minium | Row House | Brick Row House | Others | Total |
|---|---|---|---|---|---|---|---|---|
| 1 | 28,849 | 9,402 | 20,137 | 1,223 | 14,948 | 17,161 | 5,021 | 96,741 |
| 2 | 69,710 | 20,718 | 32,344 | 1,295 | 41,566 | 30,687 | 11,655 | 207,975 |
| 3 | 104,006 | 26,540 | 29,164 | 965 | 42,306 | 39,073 | 9,545 | 251,599 |
| 4 | 129,027 | 28,199 | 24,316 | 492 | 36,894 | 47,618 | 5,916 | 272,462 |
| 5 | 100,295 | 18,974 | 12,799 | 254 | 22,906 | 43,408 | 3,306 | 201,942 |
| 6 | 64,277 | 10,383 | 6,268 | 89 | 12,030 | 31,882 | 1,251 | 126,180 |
| 7 | 38,372 | 5,206 | 2,839 | 37 | 6,359 | 19,146 | 577 | 72,536 |
| 8 | 23,332 | 2,348 | 1,074 | 8 | 3,766 | 12,024 | 317 | 42,869 |
| 9 | 13,523 | 1,479 | 732 | 14 | 2,136 | 7,108 | 136 | 25,128 |
| 10 & Over | 20,928 | 1,413 | 629 | 13 | 2,769 | 9,028 | 340 | 35,120 |
| Total | 592,319 | 124,662 | 130,302 | 4,390 | 185,680 | 257,135 | 38,064 | 1,332,552 |
| Average | 4.51 | 3.88 | 3.17 | 2.52 | 3.67 | 4.59 | 3.04 | 4.17 |

Source: Population and Housing Census, NSO, 1990

## 9.2 Salient features of Housing in Bangkok

### (1) Size of Houses

Although any sufficient date analyzing size of house is not available, the number of bed rooms may represent present features. According to the Population and Housing Census 1990, as shown in Table 9.2, the average size of house per Bangkok family was 2 bed rooms plus 0.3 rooms for the other use. The average family member per unit was 4.51 persons/house for detached house and townhouse accommodate and 3.88 person/house, while 3.17 person/house and 2.52 person/house for apartment/flat and condominium respectively. Thus, apartment, flat and condominium are utilized by small households and the detached house and townhouse, by bigger households.

**Table 9.2 Size of Houses in Bangkok 1990**

| Bed Room/ Other Room | Detached House | Townhouse | Apartment, Flat | Condo-minium | Row House | Brick Row House | Others | Total |
|---|---|---|---|---|---|---|---|---|
| No. of Bed Room | | | | | | | | |
| None | 14,202 | 1,125 | 8,580 | 8 | 14,698 | 3,564 | 4,988 | 47,165 |
| 1 | 139,519 | 12,402 | 91,922 | 3,089 | 113,933 | 53,101 | 28,654 | 442,620 |
| 2 | 182,792 | 67,042 | 26,027 | 907 | 41,289 | 95,979 | 2,759 | 416,795 |
| 3 | 157,453 | 33,364 | 3,137 | 283 | 11,108 | 67,648 | 918 | 273,911 |
| 4 and Over | 97,594 | 11,029 | 517 | 103 | 4,509 | 36,342 | 718 | 150,812 |
| Unkhown | 744 | 57 | 116 | | 140 | 494 | 24 | 1,575 |
| Total | 592,304 | 125,019 | 130,299 | 4,390 | 185,677 | 257,128 | 38,061 | 1,332,878 |
| Average | 2.31 | 2.33 | 1.19 | 1.40 | 1.33 | 2.31 | 1.05 | 2.03 |
| No. of Other Room Used for Sleeping | | | | | | | | |
| None | 442,184 | 99,978 | 89,681 | 2,930 | 140,096 | 204,444 | 30,047 | 1,009,360 |
| 1 | 122,846 | 20,374 | 38,298 | 1,271 | 41,569 | 43,874 | 7,460 | 275,692 |
| 2 | 18,834 | 3,063 | 1,692 | 146 | 3,062 | 6,383 | 474 | 33,654 |
| 3 | 4,937 | 686 | 451 | | 490 | 1,376 | 39 | 7,979 |
| 4 &Over | 3,155 | 499 | 85 | 46 | 328 | 777 | 38 | 4,928 |
| Unknown | 359 | 63 | 90 | | 127 | 277 | 12 | 928 |
| Total | 592,315 | 124,663 | 130,297 | 4,393 | 185,672 | 257,131 | 38,070 | 1,332,541 |
| Average | 0.32 | 0.25 | 0.33 | 0.40 | 0.27 | 0.25 | 0.23 | 0.29 |

Source: Population and Housing Census, NSO, 1990

### (2) Tenure of Houses

46% of households in Bangkok were house owners in 1990, as shown in Table 9.3. The ownership is approximately 30% lower than the national average. Bangkok is characterized by a higher population of renters.

Most of detached houses and townhouses are owned by dwellers, however, most of dwellers at apartment and flat, condominium, and row house are renters. It is interesting that as per condominiums, half are owner and half, renters.

### (3) Location of House Supplied

Looking at the locational characteristics of recent housing development from "NHA Annual report, 1994", a considerable number of housing development was located in the area with a 20 km radius from the center of Bangkok. The housing development momentum has a clear development direction towards the North and the East, namely, Don Muang and Bang Khen Districts in the northern part of Bangkok and Min Buri and Lat Krabang Districts in the eastern part of Bangkok.

### (4) Slums

As seen in Table 9.4, a total of 1,223 locations of slums were identified in Bangkok in 1993. Out of them, some 325 slums are located in the CBD zone, while 318 and 580 slums in the urbanized and suburban zones respectively. The CBD zone decreases the number of slums, on the contrary, the urbanized and suburban zones slums are increasing in the numbers.

Approximately 1.3 million people are still dwelling in slums, which shares 22.5% of the population of Bangkok. The number of slum dwellers increased by more than 30% only for 3 years during the period from 1990 and 1993. Thus, the slums are still expanding and moving their locations from the central area to the outer area of Bangkok.

**Table 9. 3 Tenure of Living Quarters in Bangkok in 1990**

| | Detached House | Townhouse | Apartment, Frat | Condo-minium | Row House | Brick Row House | Others | Total |
|---|---|---|---|---|---|---|---|---|
| Owner | 372,148 | 93,957 | 8,324 | 2,196 | 21,950 | 117,589 | 1,255 | 617,419 |
| Hire Purchaser | 12,487 | 11,640 | 3,343 | 0 | 2,433 | 13,951 | 95 | 43,949 |
| Rent | 155,266 | 14,003 | 73,022 | 2,001 | 109,135 | 101,559 | 13,363 | 468,349 |
| Payment in Kind | 8,439 | 1,246 | 28,693 | 60 | 22,800 | 8,171 | 14,422 | 83,831 |
| Rent Free | 15,760 | 1,617 | 12,366 | 77 | 19,506 | 6,500 | 6,704 | 62,530 |
| No Payment | 17,711 | 452 | 2,807 | 58 | 8,133 | 4,573 | 1,461 | 35,195 |
| Others | 2,283 | 178 | 541 | 0 | 648 | 680 | 557 | 4,887 |
| Unknown | 6,165 | 1,268 | 902 | 0 | 1,481 | 3,204 | 110 | 13,130 |
| Total | 590,259 | 124,361 | 129,998 | 4,392 | 186,086 | 256,227 | 37,967 | 1,329,290 |
| Share | | | | | | | | |
| Owner | 63.05% | 75.55% | 6.40% | 50.00% | 11.80% | 45.89% | 3.31% | 46.45% |
| Hire Purchaser | 2.12% | 9.36% | 2.57% | 0.00% | 1.31% | 5.44% | 0.25% | 3.31% |
| Rent | 26.30% | 11.26% | 56.17% | 45.56% | 58.65% | 39.64% | 35.20% | 35.23% |
| Payment in Kind | 1.43% | 1.00% | 22.07% | 1.37% | 12.25% | 3.19% | 37.99% | 6.31% |
| Rent Free | 2.67% | 1.30% | 9.51% | 1.75% | 10.48% | 2.54% | 17.66% | 4.70% |
| No Payment | 3.00% | 0.36% | 2.16% | 1.32% | 4.37% | 1.78% | 3.85% | 2.65% |
| Others | 0.39% | 0.14% | 0.42% | 0.00% | 0.35% | 0.27% | 1.47% | 0.37% |
| Unknown | 1.04% | 1.02% | 0.69% | 0.00% | 0.80% | 1.25% | 0.29% | 0.99% |
| Total | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |

Source: Population and Housing Census, NSO, 1990

**Table 9.4 Slums in Bangkok in 1990 and 1993**

| | No. of Slum | | | No. of popultion in Slum | | |
|---|---|---|---|---|---|---|
| | 1990 | 1993 | 93/90 | 1990 | 1993 | 93/90 |
| CBD Zone* | 338 | 325 | 0.96 | 374,500 | 355,333 | 0.95 |
| Urbanised Zone* | 295 | 318 | 1.08 | 351,819 | 406,744 | 1.16 |
| Suburban Zone* | 315 | 580 | 1.84 | 220,520 | 494,193 | 2.24 |
| Total | 948 | 1,223 | 1.29 | 946,839 | 1,256,270 | 1.33 |
| Population | | | | 5,546,937 | 5,572,712 | 1.00 |
| Share of Slum in Popuation of Bangkok | | | | 17.07% | 22.54% | |

Note: * The division of the districts into the zone is same as Table 2.9.

Source: Statistical Profile of BMA

### (5) Parks and Urban Amenities

Table 9.5 shows that community facilities regarding urban amenity such as library, park and youth center. As per parks, Bangkok has a relatively small area in terms of the per capita are, which accounts for only 0.55 $m^2$/person, including open spaces. This figure is much lower than those of other large cities in the world. In terms of the zonal distribution, the CBD zone has relatively larger area of parks and open space, while the urbanized zone has the smallest. This implies that recent urbanization is not concomitant with sufficient provision on urban amenity facilities.

## Table 9.5 Parks and Urban Amenities in Bangkok in 1993

| | Libraries | Parks (sq.m) | | | | Youth | Park per Person |
|---|---|---|---|---|---|---|---|
| | | Public Park | Open Space | Play Ground | Total | Center | (sq.m/person) |
| 1 Pra Nakhon | 1 | 36,800 | 158,382 | 240 | 195,422 | 2 | 2.13 |
| 2 Khlong Toei | | | | | 0 | | 0.00 |
| 3 Klong San | 1 | | 892 | | 892 | | 0.01 |
| 4 Chatuchak | | 304,000 | 94,916 | | 398,916 | | 2.17 |
| 5 Chom Thong | 1 | | | | 0 | | 0.00 |
| 6 Don Muang | | | | | 0 | | 0.00 |
| 7 Dusit | | | 49,860 | 80 | 49,940 | 1 | 0.28 |
| 8 Taling Chan | 1 | | | 420 | 420 | 1 | 0.00 |
| 9 Thon Buri | | | 77,720 | 280 | 78,000 | 1 | 0.34 |
| 10 Bangkok Noi | | | 51,300 | 160 | 51,460 | 2 | 0.29 |
| 11 Bangkok Yai | 1 | | 100 | 40 | 140 | 1 | 0.00 |
| 12 Bang Kapi | | 560,000 | | | 560,000 | | 2.41 |
| 13 Bang Khun Thian | | | | | 0 | 1 | 0.00 |
| 14 Bang Khen | 1 | | | 320 | 320 | 1 | 0.00 |
| 15 Bang Kho Laem | | | | | 0 | | 0.00 |
| 16 Bang Sue | | | 1,200 | | 1,200 | 1 | 0.01 |
| 17 Bang Phlat | | | | | 0 | | 0.00 |
| 18 Bang Rak | | | 1,056 | 40 | 1,096 | 1 | 0.01 |
| 19 Bung Kum | | | | | 0 | | 0.00 |
| 20 Pathum Wan | 2 | 576,000 | 3,100 | 3,600 | 582,700 | 3 | 4.72 |
| 21 Prawet | 1 | | | | 0 | 1 | 0.00 |
| 22 Pom Prap | | | 4,100 | 120 | 4,220 | 1 | 0.05 |
| 23 Phaya Thai | 1 | | 680 | | 680 | | 0.00 |
| 24 Phra Khanong | | 800,000 | 1,300 | 940 | 802,240 | 3 | 3.99 |
| 25 Phasi Charoen | 1 | | | | 0 | | 0.00 |
| 26 Min Buri | | | | | 0 | 1 | 0.00 |
| 27 Yan Nawa | | | 3,612 | 300 | 3,912 | 1 | 0.04 |
| 28 Ratchthewi | | | 25,571 | | 25,571 | | 0.23 |
| 29 Rat Buruna | | 101,280 | | | 101,280 | 1 | 0.61 |
| 30 Lat Krabang | | 80,000 | | | 80,000 | 1 | 1.04 |
| 31 Lat Phrao | 1 | | | | 0 | | 0.00 |
| 32 Sam Phanthawong | | | 1,950 | | 1,950 | | 0.04 |
| 33 Sathon | | | | | 0 | | 0.00 |
| 34 Nong Khaem | | | | | 0 | 1 | 0.00 |
| 35 Nong Chok | | 56,800 | | | 56,800 | | 0.89 |
| 36 Huai Khwang | | | 34,597 | 560 | 35,157 | 1 | 0.14 |
| 37 Din Daeng | | | | | 0 | | |
| 38 Suan Luang | | | | | 0 | | |
| Bangkok Total | 12 | 2,514,880 | 510,335 | 7,100 | 3,032,315 | 26 | 0.55 |
| By Zone | | | | | | | |
| CBD Zone* | 6 | 612,800 | 370,610 | 4,440 | 987,850 | 11 | 0.52 |
| Urbanised Zone* | 2 | 405,280 | 138,425 | 980 | 544,685 | 5 | 0.33 |
| Suburban Zone* | 4 | 1,496,800 | 1,300 | 1,680 | 1,499,780 | 10 | 0.74 |
| Total | 12 | 2,514,880 | 510,335 | 7,100 | 3,032,315 | 26 | 0.55 |

Note: * Division of districts into thezone is same as Table 2.9.

Source: Statistical Profile of BMA, 1993

## 9.3 Current Housing Supply Market in Bangkok

In order to identify the current state of the housing market in Bangkok, the BEIP Team surveyed the real estate/housing information magazines available in the city as of November 1995. The results yielded several implications on suburbanization as well as the land market economy in Bangkok.

### (1) Marketable Prices of Housing Units

As seen in Table 9.6, the average price of detached houses was 2.9 million Bath/unit in Bangkok and 1.9 million Bath/unit in vicinity provinces. For townhouses, the average price was 1.5 million Bath/unit in Bangkok and 0.7 million Bath/unit in the vicinities. Housing units located in the CBD zone were the most expensive. The prices tend to decrease in accordance with the distance from the center of Bangkok.

Since the average monthly household income in Bangkok as of 1995 are deemed to be about 21,000 Baht (the BEIP Survey), if it is assumed that the affordable level of house purchase of the average family is more or less 5 times of its annual income, the marketable prices per unit for the average family is computed at 1.26 million. However, the housing supply market does not offer townhouses at such a price in the urbanized area in Bangkok. Inevitably, the average family, if it wants to buy a housing unit, should look for its house in suburban areas or outside Bangkok. This is one of the reasons from the housing market viewpoint why suburbanization is rapidly proceeding without sufficient environmental considerations.

### (2) Price Ranges of Current Housing Market

The following findings are identified though this analysis:

- Detached houses are most expensive, followed by townhouses, condominiums;
- 2-3 million Baht is the most popular pricing range for detached houses in Bangkok;
- 1-2 million Bath is the most popular pricing range for the townhouses in Bangkok,
- Less than 500 thousand Bath is the most popular pricing range for the condominiums in Bangkok.

## 9.4 Policy Directions and Planning Issues

Based on the analyses made in the preceding sections, the following planning issues and policies are identified:

### (1) Provision of Adequate Public Utilities and Amenities in Residential Areas

A urban sprawl type of residential development is observed in the suburban area of Bangkok. This eventually causes a large burden on the public sector to provide with adequate urban infrastructures, utilities and amenities. To prevent from the urban sprawl, a development guideline to meet the land use plan should be formulated.

### (2) Enhancement of Low and Middle Income Housing Provision

NHA is the responsible agency to provide the low income houses. More efforts are necessary to provide affordable housing units for them. To this end, the subcenter or new town development may be a key to launch a large scale of project. In order to facilitate the land acquisition process, a more diversified system needs to be explored, instead of the current land purchase system, such as application of Land Readjustment System, Joint Development with the private sector and/or Land Trust System.

## Tabel 9.6 Housing Prices at Current Housing Suuply Market in Bangkok

| | Bangkok | | | | BMR | | | | | | Other Areas | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CBD | Urbanized | Suburban | Sub-Total | Patun Thani | Nakon Patom | Nontaburi | Samut Prakan | Samut Sakhon | Sub-total | | |
| House for sale | | | | | | | | | | | | |
| Less than 500 Thousand Baht | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| 500 Thousand –1 Million Baht | 2 | 4 | 10 | 16 | 1 | 2 | 0 | 3 | 0 | 6 | 7 | 29 |
| 1 –2 Million Baht | 1 | 28 | 50 | 79 | 6 | 10 | 2 | 16 | 1 | 35 | 9 | 123 |
| 2 –3 Million Baht | 3 | 46 | 44 | 93 | 3 | 16 | 1 | 7 | 0 | 27 | 5 | 125 |
| 3 –5 Million Baht | 8 | 51 | 29 | 88 | 1 | 15 | 1 | 7 | 0 | 24 | 2 | 114 |
| More than 5 Million Baht | 11 | 47 | 36 | 94 | 1 | 7 | 0 | 1 | 0 | 9 | 1 | 104 |
| Total | 25 | 176 | 169 | 370 | 12 | 50 | 4 | 34 | 1 | 101 | 27 | 498 |
| Average Price | 3,721 | 2,913 | 2,737 | 2,887 | 2,063 | 2,181 | 1,376 | 1,508 | 1,500 | 1,902 | 1,463 | 2,610 |
| Townhouse for sale | | | | | | | | | | | | |
| Less than 500 Thousand Baht | 0 | 0 | 1 | 1 | 2 | 1 | 1 | 0 | 0 | 4 | 11 | 16 |
| 500 Thousand –1 Million Baht | 0 | 29 | 89 | 118 | 30 | 46 | 4 | 13 | 13 | 106 | 14 | 238 |
| 1 –2 Million Baht | 8 | 137 | 140 | 285 | 10 | 64 | 3 | 22 | 22 | 121 | 4 | 410 |
| 2 –3 Million Baht | 8 | 53 | 33 | 94 | 2 | 14 | 0 | 3 | 3 | 22 | 1 | 117 |
| 3 –5 Million Baht | 7 | 27 | 12 | 46 | 1 | 1 | 0 | 1 | 1 | 4 | 1 | 51 |
| More than 5 Million Baht | 1 | 8 | 1 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |
| Total | 24 | 254 | 276 | 554 | 45 | 126 | 8 | 39 | 39 | 257 | 31 | 842 |
| Average Price | 1,647 | 1,653 | 1,330 | 1,492 | 956 | 1,316 | 969 | 1,289 | 1,289 | 1,234 | 702 | 1,384 |
| Condominium for sale | | | | | | | | | | | | |
| Less than 500 Thousand Baht | 3 | 67 | 60 | 130 | 6 | 26 | 0 | 23 | 3 | 58 | 10 | 198 |
| 500 Thousand –1 Million Baht | 14 | 61 | 21 | 96 | 1 | 17 | 0 | 6 | 0 | 24 | 8 | 128 |
| 1 –2 Million Baht | 7 | 16 | 4 | 27 | 1 | 2 | 0 | 1 | 0 | 4 | 1 | 32 |
| 2 –3 Million Baht | 2 | 6 | 0 | 8 | 0 | 2 | 0 | 1 | 0 | 3 | 1 | 12 |
| 3 –5 Million Baht | 1 | 4 | 3 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| More than 5 Million Baht | 0 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Total | 27 | 155 | 89 | 271 | 8 | 47 | 0 | 31 | 3 | 89 | 20 | 380 |
| Average Price | 991 | 703 | 497 | 664 | 469 | 580 | – | 460 | 250 | 517 | 625 | 628 |
| Flat for sale | | | | | | | | | | | | |
| Less than 500 Thousand Baht | 1 | 8 | 4 | 13 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 15 |
| 500 Thousand –1 Million Baht | 1 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 1 –2 Million Baht | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 –3 Million Baht | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 –5 Million Baht | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| More than 5 Million Baht | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 2 | 10 | 4 | 16 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 18 |
| Average Price | 500 | 350 | 250 | 344 | – | – | – | 250 | – | 250 | – | 333 |
| Apartment for sale | | | | | | | | | | | | |
| Less than 500 Thousand Baht | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 500 Thousand –1 Million Baht | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 1 –2 Million Baht | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 –3 Million Baht | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 3 –5 Million Baht | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| More than 5 Million Baht | 1 | 5 | 0 | 6 | 0 | 0 | 0 | 3 | 0 | 3 | 0 | 9 |
| Total | 1 | 6 | 1 | 8 | 0 | 0 | 0 | 3 | 0 | 3 | 0 | 11 |
| Average Price | 7,500 | 6,667 | 750 | 6,031 | – | – | – | 7,500 | – | 7,500 | – | 6,432 |

Source: The Study Team compiles based on "Akan-Tidin (Building-Land) "(in Thai), 24-30 Nov. 1995, Public-Vattachak

### (3) One-More-Step Solution of Slum Problems

The resolution of housing issues, especially slum-problems, will be more vital for the upgrading of people's quality of living as well as the implementation of urban environment. A key for solution of the slum-problems is thought to be the implementation of an integrated policy mix, including, employment, social welfare, housing and urban planning policies.

# CHAPTER 10: NOISE AND VIBRATION

There exists areas where the noise level sometimes exceeds 80 dB (LAeq) in Bangkok. Such a high noise level may imply that noise problems should be treated as a matter of the health problem, as well as a matter of urban amenities.

## 10.1 General

### (1) Noise

Noise has two facets in the nature. One is an emotional side, such as unpleasant, uncomfortable feeling, disturbance against sleeping, and so on. Another is the irreversible effect on human hearing ability.

The former is closely related to the amenity of the city. From this point of view, the guideline level is much lower than the level of the latter facet, and may change in accordance with situations such as day time or night time, residential area or shopping area and so on.

The latter is related to human health, i.e. the hearing ability. In this point, for example, Environmental Protection Agency of U.S.A has set 70 dB (LAeq) for protection from worsening inhabitant's hearing ability. International Labor Organization (ILO) has adopted a guideline that 85 dB ($L_{Aeq, 8h}$) is the limit level, i.e., the exceeding of this level at working places is apt to cause some hearing disability in the long run for the factory worker.

It was identified from the survey conducted by the Study Team that the daytime noise level at Patthanakan junction exceeds 80 dB (LAeq) and reaches the level of 85 dB (LAeq). This situation is likely caused by the heavy traffic and the covering effects of flying-over road. It can generally be said that this noise level can be construed as an issue on public health.

People's great concern about air pollution has been focused on TSP so far, but the noise problem is considered to be another significant issue of urban environment soon or later. It is the case that awareness of pollution problem by inhabitants sometimes delays after its actual occurrence.

### (2) Vibration

Main characteristic of vibration problems is emotional and local, similar to noise problems. On the contrary, according to the survey result by the Study Team in December 1995, vibration problems do not seem so severe as noise problems.

## 10.2 Assessment on Present Conditions

### (1) Roadside Noise Level in the Central Area of Bangkok

Regarding noise levels in Bangkok, published data is very little. Available information is only graph, so it is difficult to find out clear figures of noise data. According to "Pollution Situation in Thailand 1994", it is reported that roadside 24 hours noise level ($L_{Aeq,24}$) are between 70 to 85 dB(A). It can be observed that the similar situation is prevailing at major roadsides in Bangkok.

### (2) Noise Survey Results of the JICA Study Team

The noise level survey was carried out in December 1995 at 5 survey points for road traffic noise, 5 survey points for industrial noise and 2 survey points for railway noise, as shown in Fig. 10.1. The results are summarized in Tables 10.1. to 10.3.

**Table 10.1 Roadside Noise Level (LAeq, dB)**

| Location | Road | Morning | Noon | Evening | Night |
|---|---|---|---|---|---|
| Din Daeng | Viphawadi Rangsit Road | 80 | 79 | 80 | 79 |
| Lumphini Park | Rama 4 Road | 83 | 81 | 80 | 81 |
| Benjasiri Park | Sukhumvit Road | 73 | 65 | 76 | 76 |
| Ramkhamhaeng-Patthanakan Crossing | Patthanakan Road | 78 | 84 | 83 | 82 |
| Near Kasem Phihaya School | Sukhumvit Soi 71 | 79 | 79 | 82 | 80 |

Note: Morning:05:00-09:00,Noon:10:00-14:00,Evening:15:00-20:00, Night:20:00-9:00

Source: JICA Study Team

**Table 10.2 Factory Related Noise Level (LAeq, dB)**

| Location | District | Morning | Noon | Evening | Night |
|---|---|---|---|---|---|
| Ceramic | Phra Khanong | 65 | 64 | 63 | 64 |
| Metal (1) | Phra Pradaeng | 61 | 66 | 65 | 65 |
| Metal (2) | Phra Pradaeng | 70 | 75 | 76 | 76 |
| Utility | Muang | 77 | 77 | 79 | 79 |
| Fuel | Phra Khanong | 61 | 71 | 63 | 61 |

Note: Morning:05:00-09:00,Noon:10:00-14:00,Evening:15:00-20:00, Night:20:00-24:00

Source: JICA Study Team

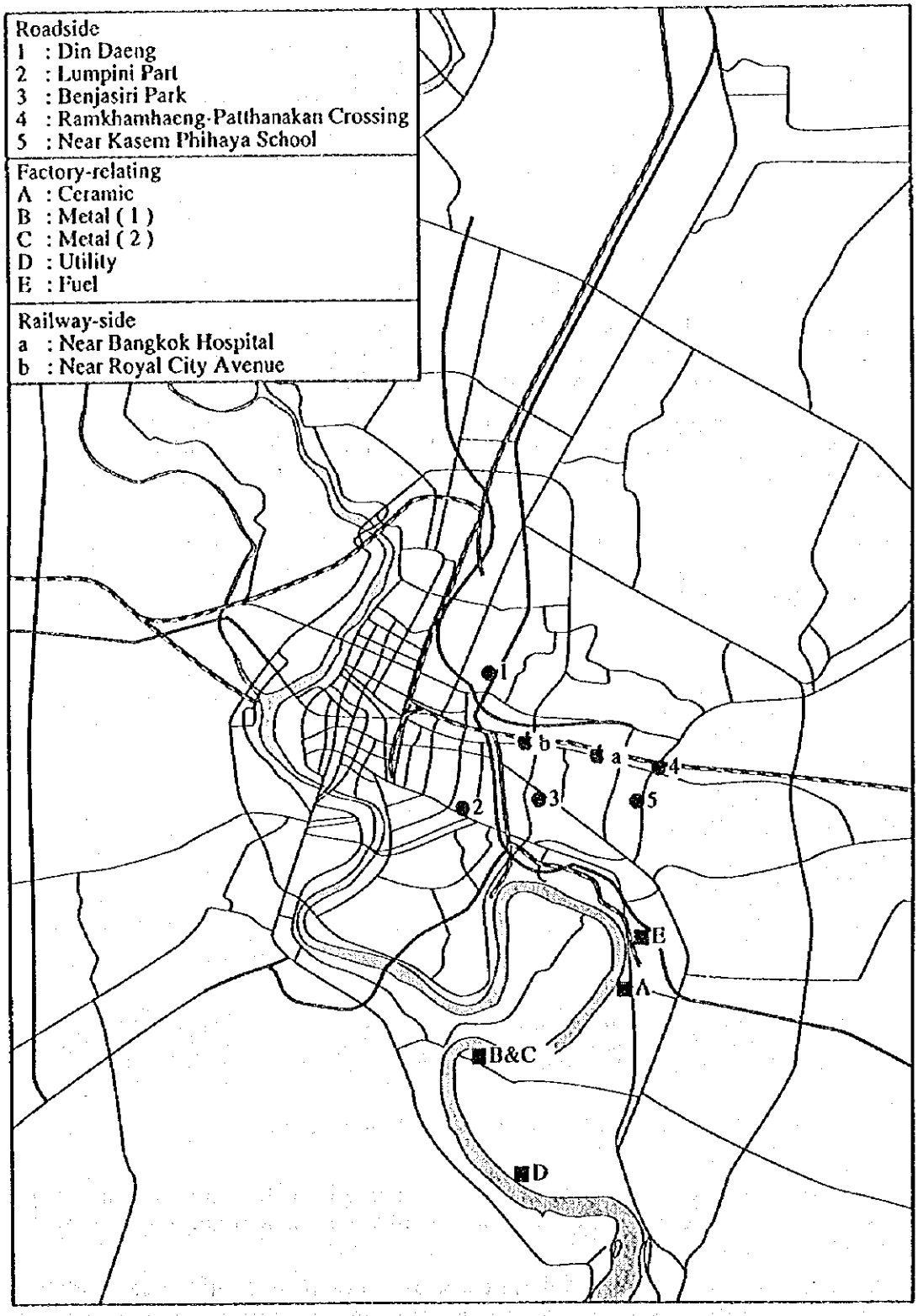



**Fig. 10.1 Locations of Monitoring Points**

**Table 10.3 Railway Side Noise Level ($L_{Aeq}$ dB)**

| Location | Noise | Location | Noise |
|---|---|---|---|
| Near Bangkok Hospital | 81-89 | Near Royal City Avenue | 83-89 |

Note: Morning:05:00-09:00,Noon:10:00-14:00,Evening:15:00-20:00,
Night:20:00-24:00

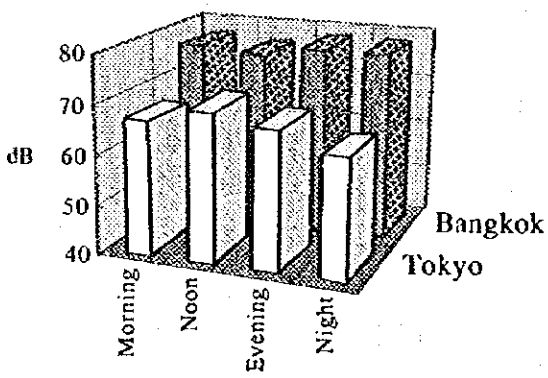
Source: JICA Study Team

### (3) Noise Level in the Central Area of Bangkok

Available noise data and the survey data by the Study Team are consistent with each other. These noise values are considered to be considerably high. The similar situation is observed to be prevailing at major roadsides in Bangkok.

To assess the situation, a comparative analysis may be useful. Tokyo is selected to compare Bangkok. The data of the JICA Study Team were summarized to median values because the data of Tokyo are median values. The result is shown in Fig 10.2.

As seen in the figure, there exist remarkable differences between both cities. These differences are around 10dB. The difference of 10dB means that Bangkok's sound energy is 10 times as large as that in Tokyo. Major road side of Bangkok seems to be the crucible of sound energy.




| | Bangkok | Tokyo |
|---|---|---|
| Morning | 77 | 67 |
| Noon | 76 | 70 |
| Evening | 78 | 68 |
| Night | 78 | 64 |

Note: The noise levels are average of median values of selected points, which are the 5 points of the JICA Study Team for Bangkok, and 68 roadside noise stations of central wards for Tokyo in 1993 (2536), processed by JEA. Chiyoda-Ku, Chuou-Ku, Minato-Ku and Shinjuku-Ku of Tokyo are selected for the central wards in this case.

**Fig. 10.2 Noise in Bangkok and Tokyo**

As seen in Table 10.1, a number of noise levels exceed 80 dB, and there are a few reaching 85 dB. These figures imply that noise should be mitigated not only for amenity but for protection from hearing disability.

Noise levels related to factories and railways are shown in Tables 10.2 and 10.3. Taking into account the characteristics of noise, it cannot be necessarily generalized to assess these conditions and the causes. Because the feature of boundary noise problems has the nature of site specific local problem, and depends on various conditions such as operation hour, relation to traffic, inhabitants awareness, and so on.

Recently noise level map of Bangkok metropolice which was one km in central zone and two km in other area grid map was made by ERTC. It reports that noise level of many grids exceed Leq 70 dB(A) in day time, and considerable grids exceed in night time.

### (4) Standard and Regulation

To mitigate noise problems, ambient noise standards and noise regulations for vehicle, factory and construction are an important basis for policy making and administrative actions. Formalizing of the standard and regulations which are appropriately applicable to its country is an essential matter. Proper standards and regulations also play an important role of education and enlightenment of people towards mitigating the noise problem. Regarding standards and regulations applicable to the Thai environment, the following items should be further discussed:

**Table 10.4 Considerations on Standards and Regulations**

| | Items |
|---|---|
| Standards | (1) For reviewing the roadside noise, the guideline set by US. Environmental Protection Agency, i.e. Leq 70 dB, is thought to be applied. This figure is not for amenity but for protection from hearing disability. |
| | (2) Regional characteristics such as industrial, commercial and residential activities might not be covered. |
| | (3) Noise in night might not be treated separately. |
| Regulations | Regulations against vehicle and commuter boat are already implemented. |
| | (1) But introduction of sound level limit at boundary of factory site is not yet. |
| | (2) Introduction of construction noise limit according to time is not yet. |

### (5) Vibration Survey Results of the JICA Study Team

The vibration level survey was carried out by the Study Team in December 1995, and its results are shown in Tables 10.5. and 10.6.

The threshold value of human sensitivity for vibration is 55 dB. The significant effect by vibration to human health is thought to start at 90 dB or higher level. Taking these items into consideration, the information by Tables 10.5 and 10.6 are thought to be imply us that vibration problem is not severe as noise.

**Table 10.5 Roadside vibration Level (90 percentile, dB)**

| Location | Road | Morning | Noon | Evening | Night |
|---|---|---|---|---|---|
| Din Daeng | Viphawadi Rangsit Road | 56 | 56 | 52 | 56 |
| Lumphini Park | Rama 4 Road | 53 | 53 | 52 | 55 |
| Benjasiri Park | Sukhumvit Road | 46 | 47 | 47 | 45 |
| Ramkhamhaeng-Patthanakan Crossing | Patthanakan Road | 56 | 58 | 55 | 51 |
| Near Kasem Phihaya School | Sukhumvit Soi 71 | 55 | 54 | 55 | 45 |

Note: Morning:05:00-09:00,Noon:10:00-14:00,Evening:15:00-20:00, Night:20:00-24:00

Source: JICA Study Team

Table 10.6 Factory Boundary vibration Level (90 percentile, dB)

| Industry | District, Road | Morning | Noon | Evening | Night |
|---|---|---|---|---|---|
| Ceramic | Phra Khanong | 44 | 46 | 49 | 41 |
| Metal | Phra Pradaeng | 44 | 53 | 52 | 52 |
| Metal | Phra Pradaeng | 54 | 60 | 54 | 56 |
| Utility | Muang | 52 | 52 | 52 | 52 |
| Fuel | Phra Khanong | 36 | 40 | 44 | 40 |

Note: Morning:05:00-09:00,Noon:10:00-14:00,Evening:15:00-20:00, Night:20:00-24:00

Source: JICA Study Team

## 10.3 Policy Directions and Planning Issues

It should be noted that traffic noise issues in the central area and sub-urban areas of Bangkok have different characteristics. For the center of Bangkok, the current noise situation should be mitigated, while in sub-urban areas a main issue of noise is that the noise situation should not be worsened than the present status.

Further study aspects in the center of Bangkok are as follows:

- Improvement of motor vehicle, especially motorcycle, samlor, heavy bus and light to heavy truck ;
- Improvements of road structure, such as elongation of eco-corridor, planting of noise shielding trees, and flatness of pavement ;
- Adequate management of construction work ;
- Consideration for avoiding construction of flying-over in the city canyon ;
- Effluence of traffic ; and
- Public relation of noise situation.

Relating to sub-urban areas the study issues are mainly the built-in of noise mitigating concepts into city planning matters as below:

- By-path road construction ;
- Preparing wide sidewalk which has noise absorbing trees ; and
- Zoning of region.

## 10.4 Planning Targets and Proposed Measures

Based on above discussion, the main issue is focused on mitigation of motor vehicle noise.

Table 10.7 PlanningTargets and Proposed Measures

| Target | Measures |
|---|---|
| 1. Mitigation of motor vehicle noise | (1) Implementation of regulation and inspection procedure against motor vehicle noise |
| | (2) Improvement of road structures |
| | (3) Attainment of the Leq 70 dB level at all road side area |
| 2. Future integrated policy | (1) Policies for up-grading of "Quality of Living" |
| | (2) Depending on the characteristics of the area, such as residential, commercial and industrial |

# CHAPTER 11: MICRO STUDY

## 11.1 Objective and Scope of the Micro Study

### (1) Objectives

As discussed in the preceding chapters, Bangkok environmental issues are not homogenous but heterogeneous in the nature. Therefore, measures to be undertaken should employ a wide variety of tools including institutional, administrative as well as implementation of infrastructure projects. Since environmental problems always appear at local level, the solutions need to address local reality with concrete images.

The objective of this micro study is to seek one of the appropriate ways to solve the local problems by urban planning approach, based on the implications derived from the macro studies.

### (2) Selected Model Areas

Six areas are selected as the model areas with typical environmental problems for which urban planning tools should be employed. The six areas have respective attributes as follows, and the locations are shown in Fig. 11.1.

1) **Lat Krabang Subcenter Zone**: As a model of guided urbanization of subcenter zone development in the eastern Bangkok area where vast potentials are still available to accommodate increasing population and job places.

2) **Taling Chan Subcenter Zone**: As a model of MRT-driven urbanization in the western Bangkok with great potential for rapid urbanization, where disorderly sprawl would take place without infrastructure-led development.

3) **Part of Khlong Toey**: As a model of improvement of road network in the highly built-up area, in relation to the forthcoming MRT systems and restructuring of the inner city areas.

4) **Din Daeng Renewal**: As a model of the public housing renewal project (NHA) in the inner city in association with public projects of New Bangkok City Hall, MRT stations and other new urban projects in the vicinities. Public transportation-based urban re-structuring is the main theme.

5) **Chao Phraya River-front Renewal**: As a mode of Chao Phraya River-front redevelopment by relocation of existing less-functioning warehouses and factories, and new land use for a purpose of environmental facilities development.

6) **Rathanakosin Historical Conservation**: As a model of institutional building for historical conservation based on a review of the on-going Master Plan Study by the

national committee for Rathanakosin Conservation. The conservation of historical assets must be one of important environmental policies.

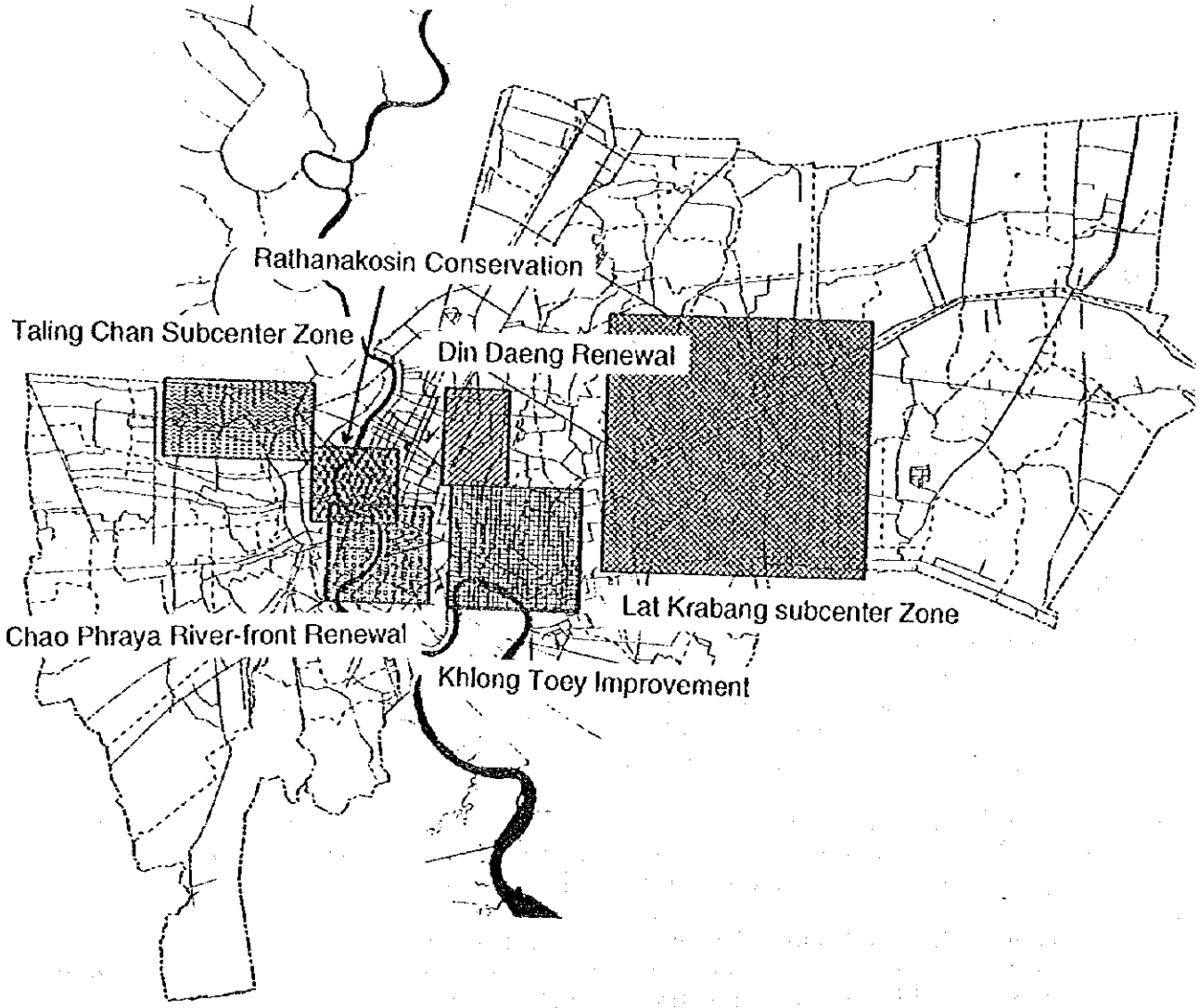



**Fig. 11.1 Locations of Micro Study Model Areas**

## 11.2 A Physical Model of Subcenter Zone Development

The basic strategies and planning concepts of "Subcenter Zone Development" are discussed in Section 9.4, Chapter 9: A Vision of Spatial Framework. This section presents physical planning ideas, taking up a model of Minburi/Lat Krabang Subcenter Zone

### (1) A Conceptual Model of Minburi/Lat Krabang Subcenter Zone

A model of Subcenter Zone Development with an about half million population imagining, was conceptually depicted to study the needs of land development, infrastructures and road network systems, as shown in Fig. 11.2.

This urban model seeks a physical feature of Environment-friendly Urban Development, considering the following planning concepts:

Rational Land Use Pattern

Three concepts are employed for rationalization of the land use:

- Moderate population density,
- Concise activity center area; and
- Sufficient open space for the environment and public uses.

Given a population density of 140 persons/ha in the average, a total land area of 3,500 ha (about 6 Km x 6 Km) needs to be prepared to accommodate half million population, and with the employment density of 200 jobs/ha, the land area of 750 ha is used for work places for the self-sustained job-housing balance.

The areas to accommodate some special urban functions such as higher educational and government facilities as well as light industries and warehouses, some of which are to be relocated out of the Bangkok central areas, are prepared. Given quality environment, this subcenter zone will be suitable for location of R & D and information-related business.

The area for parks and open space should be prepared for location of public utility facilities such incineration plants, energy facilities and/or resource recycling centers.

Mass Transit-based Urban Development

Stations of MRTs or SRT railway function as activity centers of the new town, providing with station plazas and frontage areas where business, commercial and other urban service facilities are accumulated. Such large traffic generators should be located adjacent to the stations so that workers and business persons may approach them on foot to/from the stations.

Water Channel-cum-Road System

Major streets connecting with MRT stations (Lat Krabang and Minburi) are planned as "**Eco-boulevard**" as an axis of the subcenter zone, as illustrated on Fig. 11.3. The eco-boulevard is structured with secondary roads and drainage channels in association with greens. These channels form "Green-Water Network" over the subcenter zone.

Feeder Public Transport Systems

Bus service routes are connected directly with MRT stations as the feeder transport service network. The feeder bus routes are served so that all residents can reach any bus stop within 500 meter walk.

Hierarchical Road Network System

The subcenter zone is served by regional arterial highway(s), or express way and arterial roads. The secondary roads need to be networked with at least 2 km interval, and the tertiary roads are served with 500-1,000 meter interval.

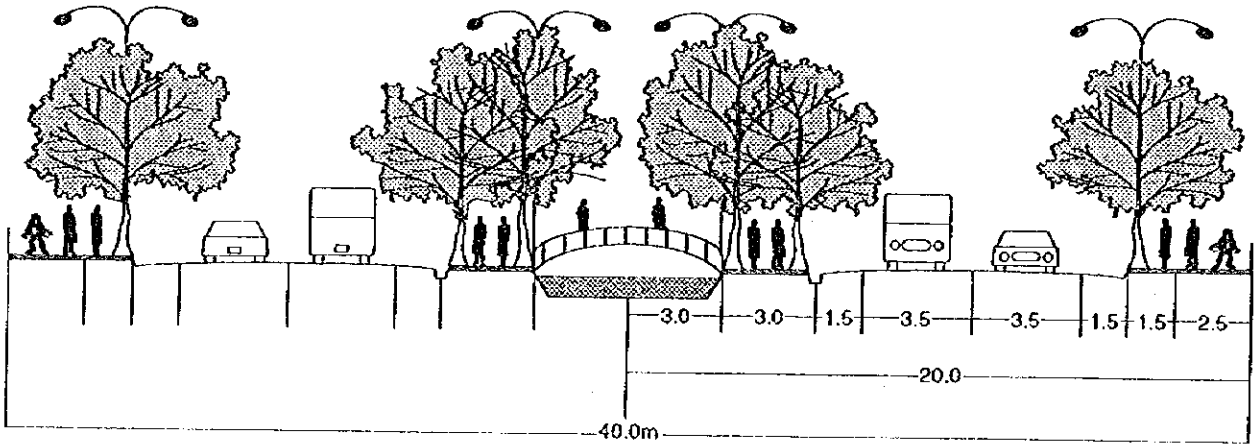
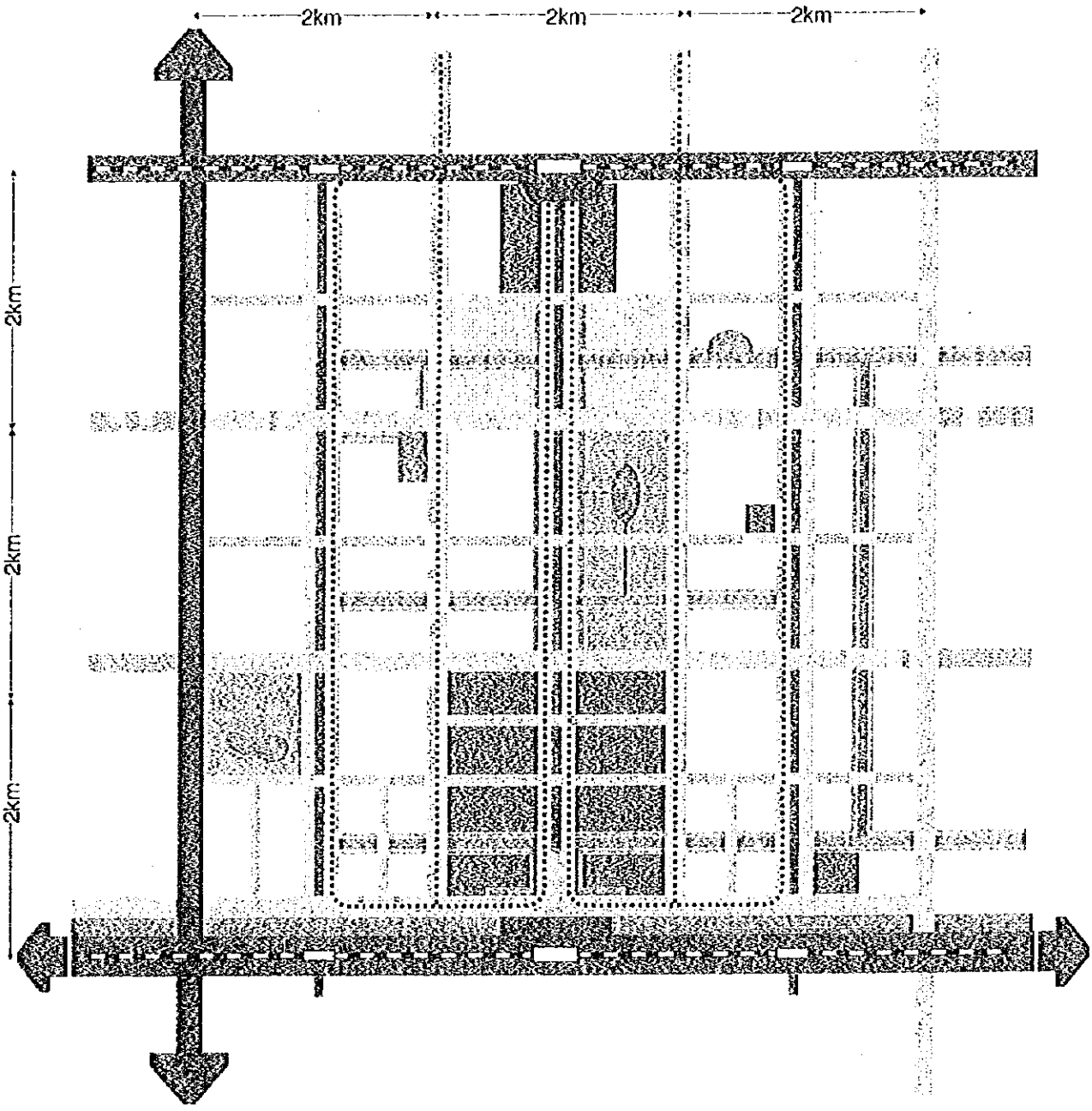



**Fig. 11.3 A Proposal for Design of "Eco-boulevard" as an Axis of Subcenter Zone**




LEGEND

| Land Use | Transportation |
|---|---|
| Business, Commercial | Regional Arterial Road (Express Highway) |
| Higher Education and Government Services | Arterial Road |
| R & D and Information, Light Industrial | Secondary Road |
| Park, Open Space and Public Utilities | Tertiary (Local) Road |
| Residential | Mass Transit System and Station |
| Drainage Channels and Retaining Ponds | Bus Service Routes |

**Fig. 11.2 A Conceptual Urban Model of Subcenter Zone Development with 500 Thousand Population**

## 11.3 Major Planning Considerations on Six Model Areas

The planning considerations taken for these six model areas are summarized in Figs. 11.4 through 11.9. The measures/strategies proposed in this table are examples, but necessary to materialize the plans proposed in the macro study.

## 11.4 Urban Environmental Quality Up-grading from Urban Design

The quality of urban environment depends remarkably on quality of urban design. Many attempts for this purpose have been presented in many cities over the world. Some of them are applicable

### (1) Appreciation of Thai Traditional Urban Design Principles

The typical urban design based on the Thai tradition which can be seen in the Rathanakosin is appreciably designed with the water-friendly environment. The street with plenty greens make a lot of shade in the city to alleviate the severe tropical climate and mitigate somewhat the dusty air pollution. Such traditional design principles should be utilized for urban design even in the busy areas.

### (2) Functional Intermodal Transfer Facilities and Pedestrian Environment

Convenient and comfortable systems for intermodal transfer facilities need to be developed with special emphasis as urgent projects, as recommended in the BEIP Study. In particular, the transfer facilities between MRTs and buses are important. There are many examples of the design of these facilities in Japan, Singapore and European countries for reference.

### (3) Building Set-back and Street Design

The current Building Code has stipulated a building set-back regulation. This regulation should be further strengthen particularly those located along some selected major streets which are planned as symbolic amenity streets or boulevards with greens and street furniture. The frontage space created by the set-back should be utilized as semi-public space for pedestrians as well as landscape belts.

Fig. 11.4

| NAME OF THE PROJECT | LAT KRABANG SUBCENTER ZONE DEVELOPMENT |
|---|---|

## TARGETS OF ENVIRONMENTAL IMPROVEMENT

To facilitate the guided-subcenter zone development initiated by the public sector in the eastern bank of Bangkok, aiming at Mass Transit-driven urban development.

## CHARACTERISTICS OF THE LOCATION

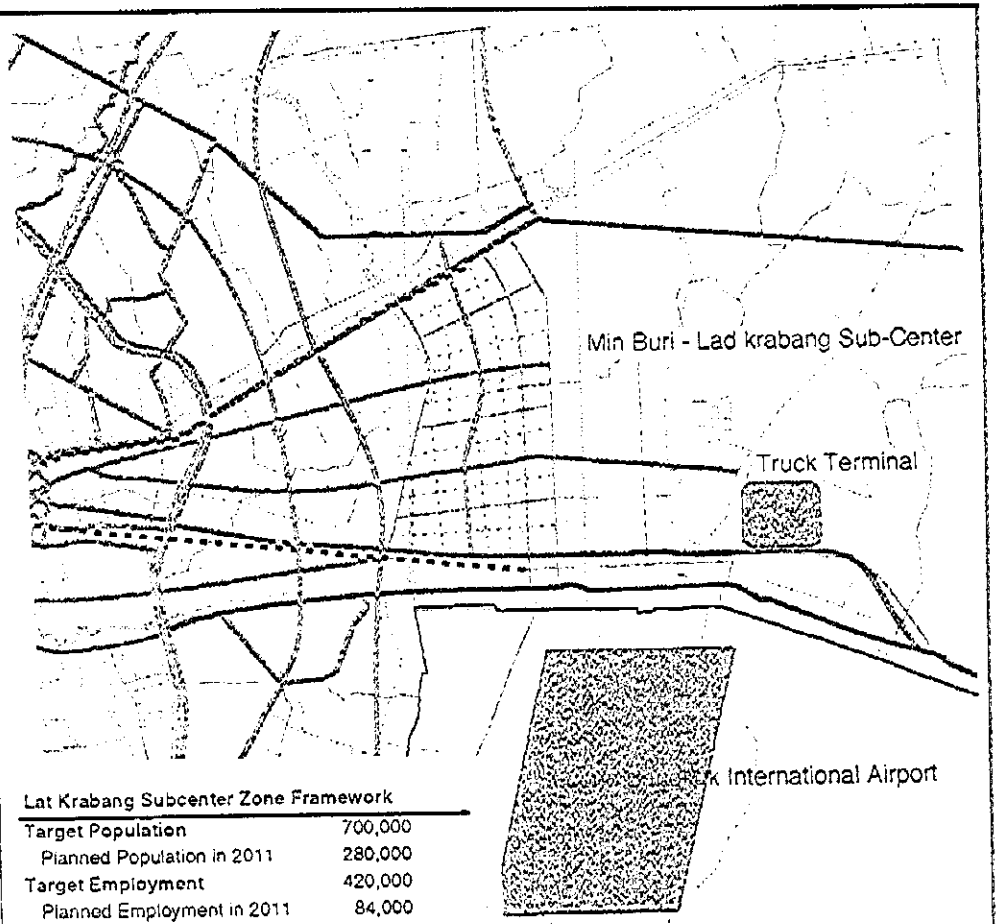
- The Project area is located in the highly urbanization potential areas in the future, given the completion of the on-going major projects such as the Second Bangkok International Airport, Bangkok-Chonburi Highway and Outer Ring Road.
- The SRT Eastern Line presently provides commuter trains. The extension of MRT (Red Line) is planned.

## PLANNING CONCEPTS

- Development of the subcenter zone with 700 thousand population, integrating the existing built-up areas and the newly developed areas;
- Development of infrastructure-led urban area with a housing-and-job balance, inducing business, light industrial, higher educational, R&D and Information, government services, cargo-distribution, commercial and residential facilities;
- Improvement of environmental and transport infrastructures in the existing built-up areas as part of the subcenter zone development;
- Development of an environment-friendly urban system, managing and designing water and greens;
- Development of an intensive bus transport service network linked with MRT stations so that any resident can reach a bus stop by 500 m walk.

## FOR THE IMPLEMENTATION

- To formulate Master Plan and Feasibility Study, reviewing the previous study of "Metropolitan Subcenter Planning" by MIT Consultant Team;
- To designate the subcenter zone in the legal framework of Urban Planning Act;
- To explore the implementation system in consideration of application of "Land Readjustment System", and/or "Land Trust System" to deliberately involve the landlords;
- To organize the implementation body jointly with the public and private sector, including the MRT operators;




| Lat Krabang Subcenter Zone Framework | | |
|---|---|---|
| Target Population | 700,000 | |
| Planned Population in 2011 | 280,000 | |
| Target Employment | 420,000 | |
| Planned Employment in 2011 | 84,000 | |
| Area of Subcenter Zone (ha) | 6,700 | 100% |
| Existing Built-up Area | 1,130 | 17% |
| Future Expansion of Built-up Area | 850 | 13% |
| Planned Development Area | 4,720 | 70% |
| Land Use Composition (ha) | | |
| Commercial & Business | 350 | 5% |
| Production/industry | 350 | 5% |
| Residential | 2,950 | 44% |
| Public Service Facilities | 700 | 10% |
| Parks, Open space and Reserve | 1,350 | 20% |
| Transpon Facilities | 1,000 | 15% |
| Existing Core Local Center | Minburi | |
| Available Mass Transit System | Red & Orange Lines, SRT | |

Fig. 11.5

| NAME OF THE PROJECT | TALING CHAN SUBCENTER ZONE DEVELOPMENT |
|---|---|

## TARGETS OF ENVIRONMENTAL IMPROVEMENT

To facilitate the guided-subcenter zone development initiated by the public sector in the western bank of Bangkok (Tonburi Side), aiming at Mass Transit-driven urban development.

## CHARACTERISTICS OF THE LOCATION

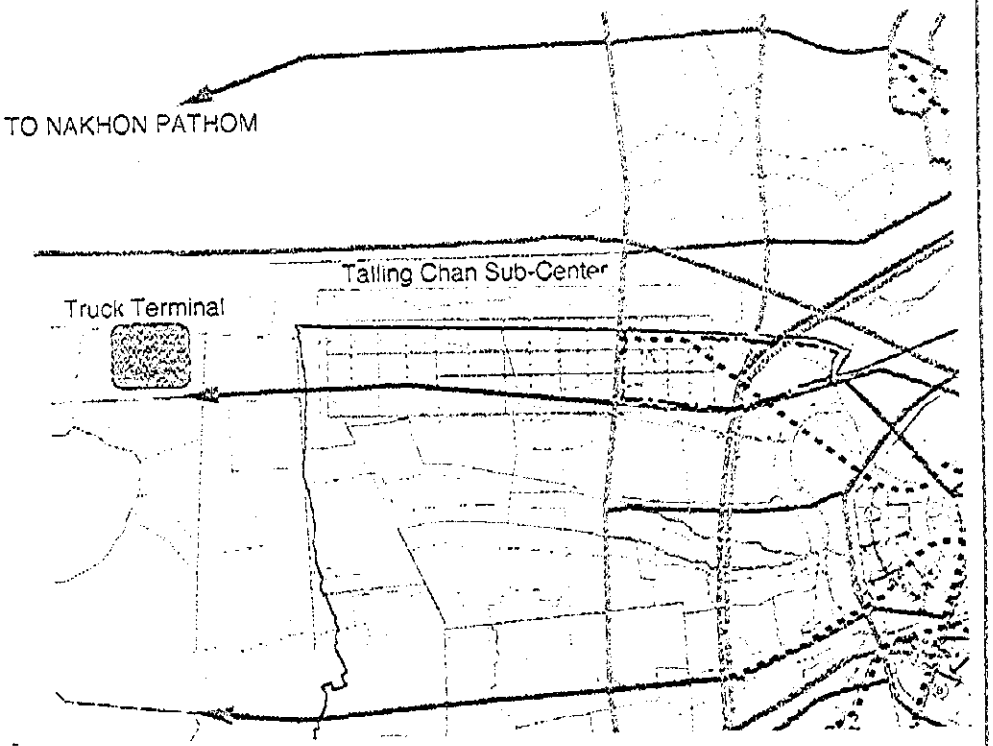
- ☐ The Project area is located in the urbanization potential areas where a number of subdivision projects are recently emerging without adequate infrastructures;
- ☐ The SRT Southern Line presently provides commuter trains from the Taling Chan Station. The extended MRT (Red Line) is planned to serve this corridor.
- ☐ Major arterial roads such as Outer Ring Road and Middle Ring Road 'Expressway) area scheduled to serve the Project area.

## PLANNING CONCEPTS

- ☐ Development of the subcenter zone with 500 thousand population, integrating the existing built-up areas and the newly developed areas;
- ☐ Development of infrastructure-led urban area with a housing-and-job balance, inducing business, higher educational, government services, commercial and residential facilities;
- ☐ Improvement of environmental and transport infrastructures in the existing built-up areas as part of the subcenter zone development;
- ☐ Development of an environment-friendly urban system, managing and designing water and greens;
- ☐ Development of an intensive bus transport service network linked with MRT stations so that any resident can reach a bus stop by 500 m walk.

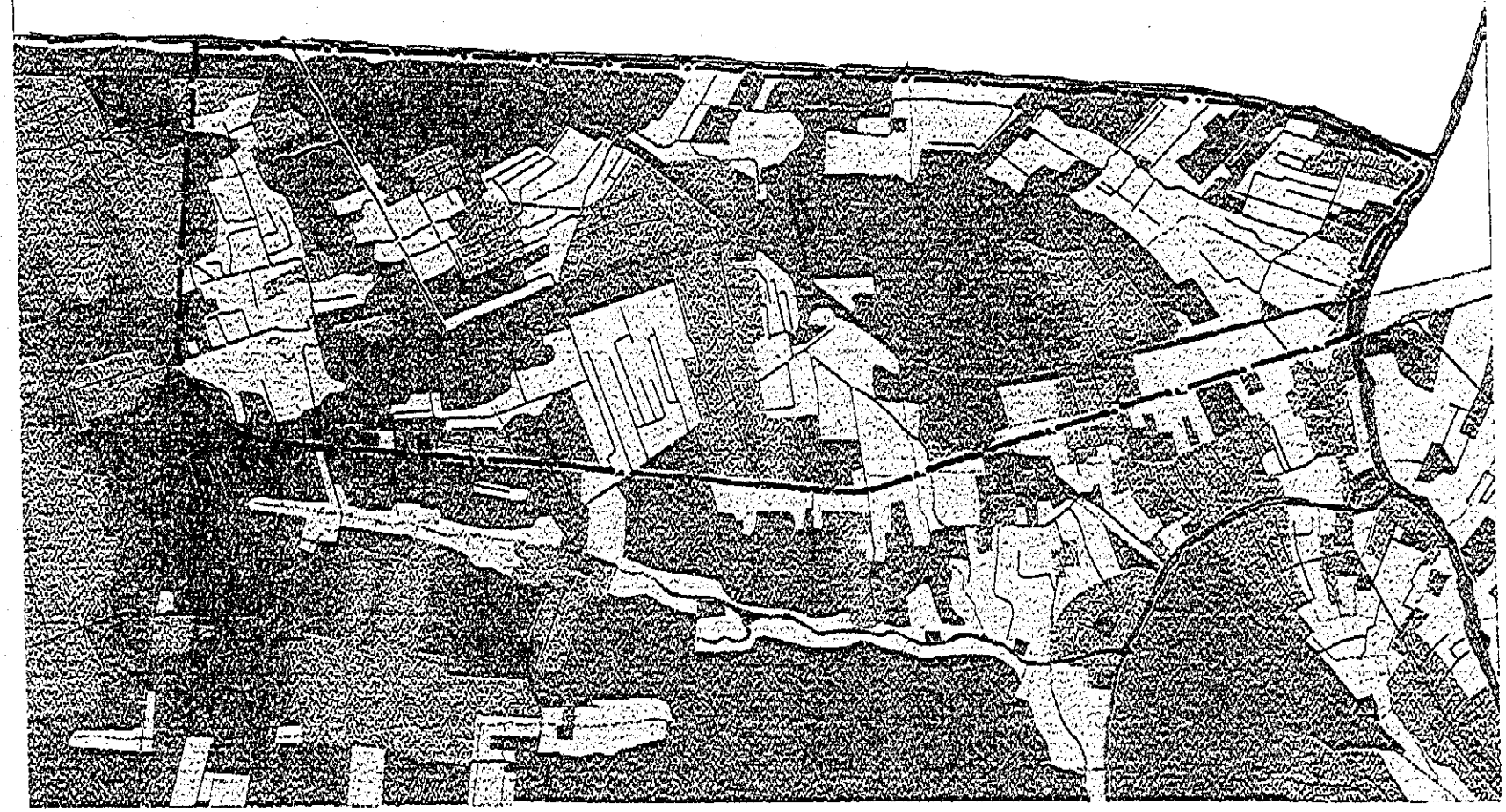
## FOR THE IMPLEMENTATION

- ☐ To formulate Master Plan and Feasibility Study, reviewing the previous study of "Metropolitan Subcenter Planning" by MIT Consultant Team;
- ☐ To designate the subcenter zone in the legal framework of Urban Planning Act;
- ☐ To explore the implementation system in consideration of application of "Land Readjustment System", and/or "Land Trust System" to deliberately involve the landlords;
- ☐ To organize the implementation body jointly with the public and private sector, including the MRT operators;




| Taling Chan Subcenter Zone Framework | | |
|---|---|---|
| Target Population | 500,000 | |
| Planned Population in 2011 | 150,000 | |
| Target Employment | 300,000 | |
| Planned Employment in 2011 | 45,000 | |
| Area of Subcenter Zone (ha) | 4,800 | 100% |
| Existing Built-up Area | 700 | 15% |
| Future Expansion of Built-up Area | 660 | 14% |
| Planned Development Area | 1,040 | 22% |
| Land Use Composition (ha) | | |
| Commercial & Business | 240 | 5% |
| Production/industry | 100 | 2% |
| Residential | 2,280 | 48% |
| Public Service Facilities | 500 | 10% |
| Parks, Open space and Reserve | 960 | 20% |
| Transport Facilities | 720 | 15% |
| Available Mass Transit System | Red Line and SRT | |

## CURRENT LAND USE

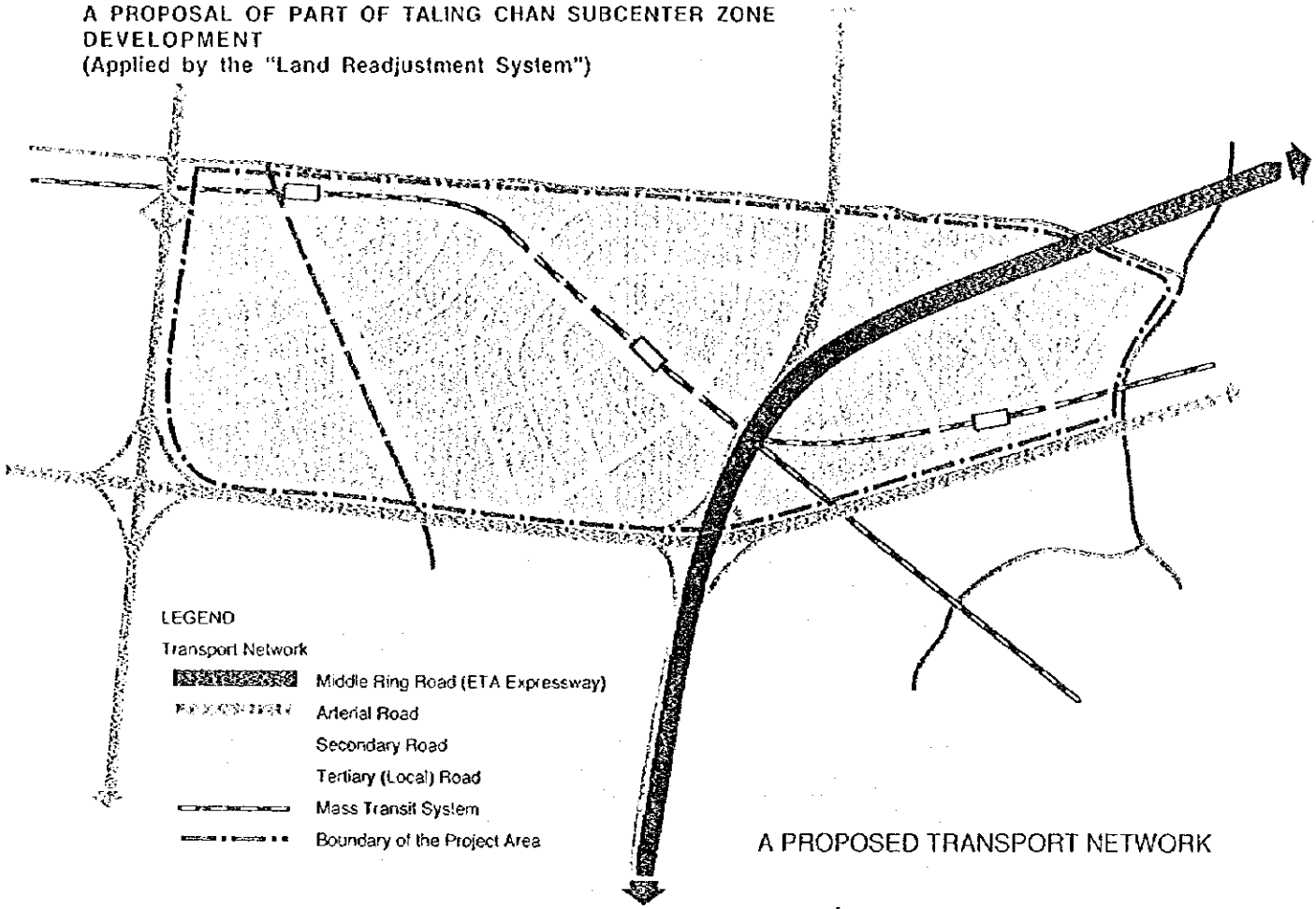


The Land use within the Project Area was surveyed by the BEIP Team in September 1996.

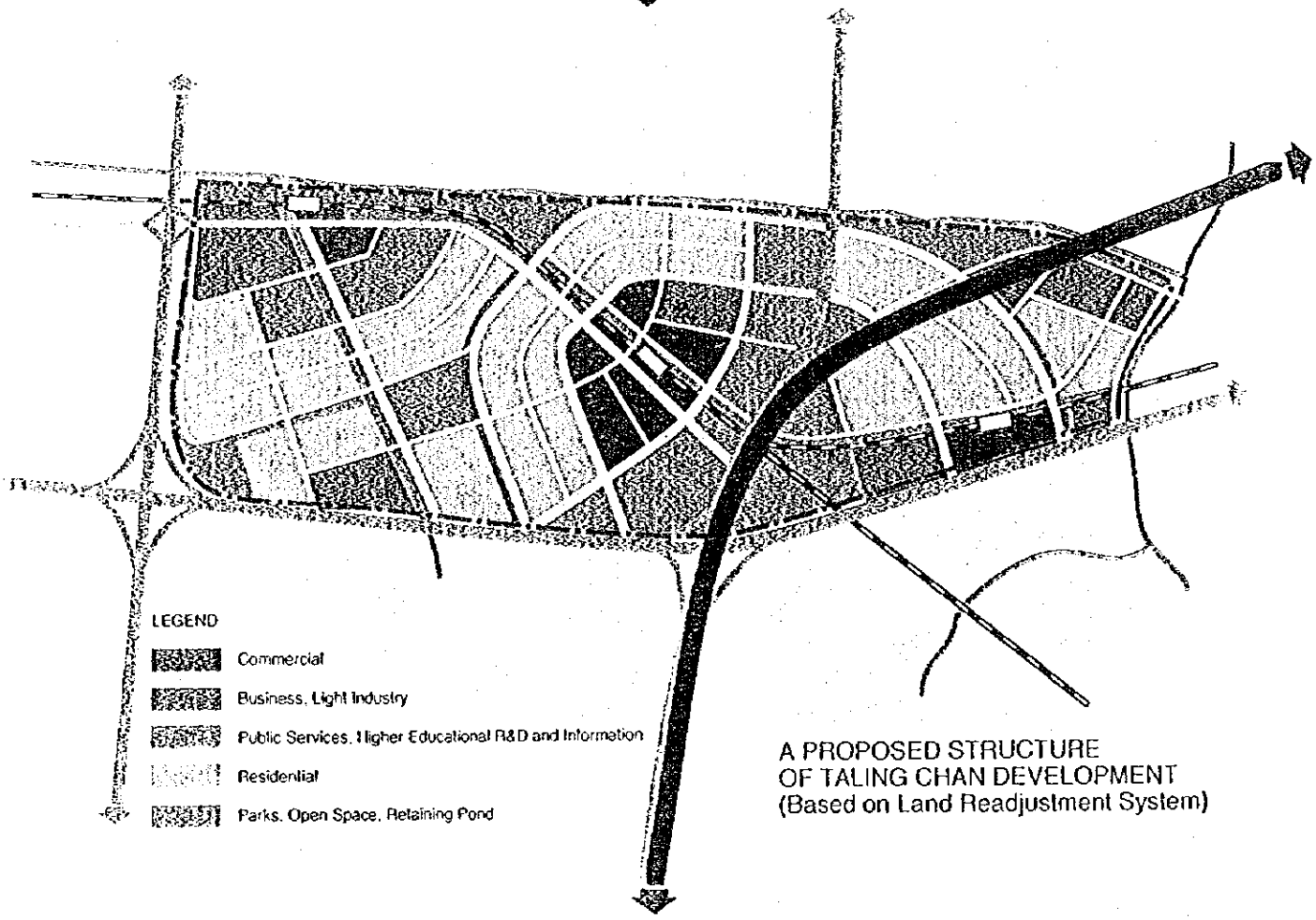
- Warehouse Area
- Government and Public Services
- Open Space/Agricultural
- Conservation
- Park
- High Density Residential
- Middle Density Residential
- Low Density Residential
- Commercial
- Industrial
- School
- Religion
- River

SOURCE : AERAIL PHOTOS TAKEN IN MARCH , 1995.

A PROPOSAL OF PART OF TALING CHAN SUBCENTER ZONE DEVELOPMENT
(Applied by the "Land Readjustment System")




A PROPOSED TRANSPORT NETWORK




A PROPOSED STRUCTURE
OF TALING CHAN DEVELOPMENT
(Based on Land Readjustment System)

Fig. 11.6

| NAME OF THE PROJECT | KHLONG TOEY BUILT-UP AREA IMPROVEMENT |
|---|---|

## TARGETS OF ENVIRONMENTAL IMPROVEMENT

To improve the environmental conditions in the built-up area of part of Khlong Toey District, focusing on the improvement of transport system with MRT, bus and soi .

## CHARACTERISTICS OF THE LOCATION

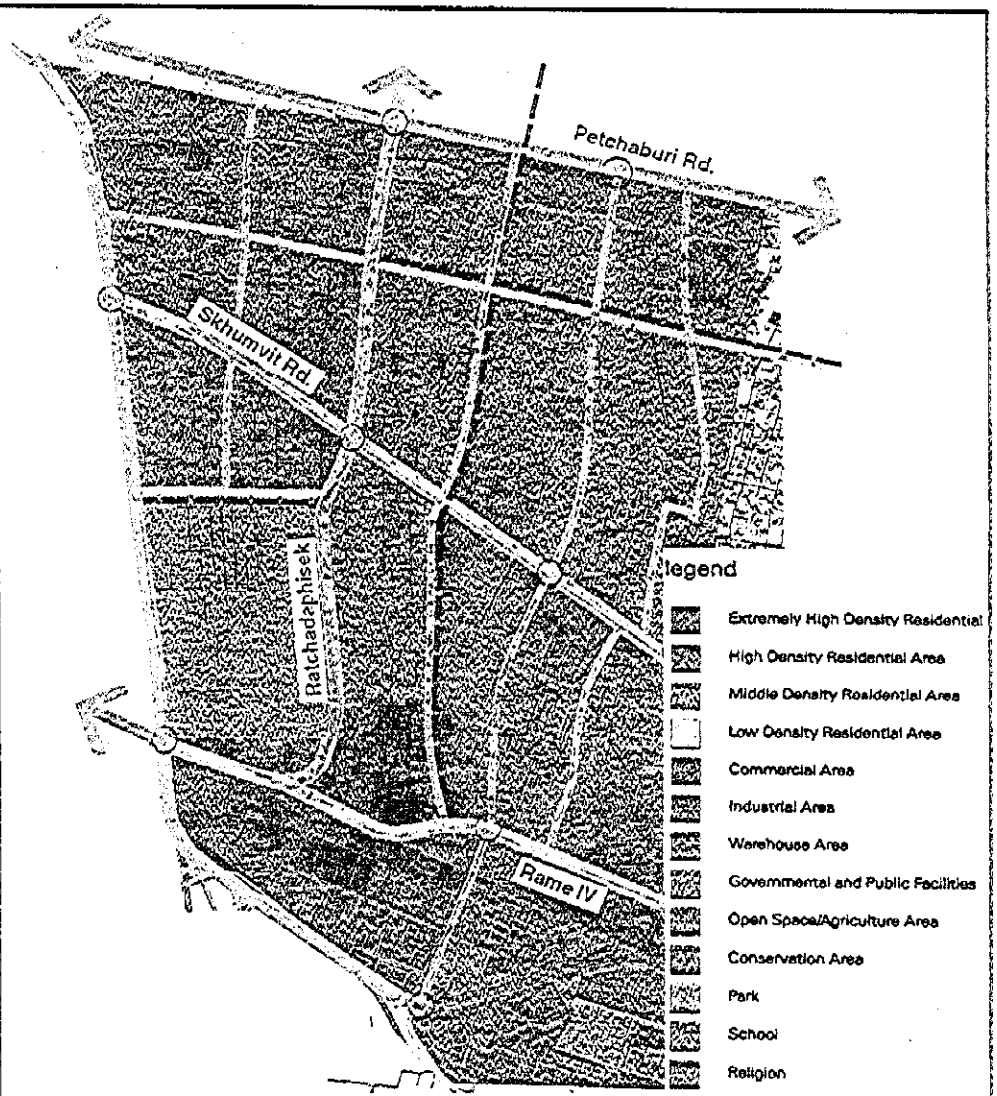
- ☐ The Project area is located in the highly urbanized area where a wide variety of urban economic and housing functions have already been accumulated, thereby making the development of an adequate road network more difficult.
- ☐ The current construction booming encourages the scrap-and-built process in the area, and 10-15% of the land has been changed in its land use for last 7 years.

## PLANNING CONCEPTS

- ☐ Restructuring the existing soi-system to a functionally networked access road system in association with the forthcoming MRT (Green Line) on Skhumvit Road;
- ☐ Development of "Public Transport Corridor" on Skhumvit Road with adequate pedestrian environment;
- ☐ Creation of semi-public space for environmental infrastructures and amenity facilities, by enhancing an institutional tool of the "Building Set-back" regulation.
- ☐ Application of "Land Readjustment Scheme" for selected areas without adequate road network.

## FOR THE IMPLEMENTATION

- ☐ To review the previous Master Plan Study for Khlong Toey District, and build the Action Plan in the short- and medium-term;
- ☐ To coordinate the legislative inter-relation between the current Urban Planing Act and Building Code in terms of land use, building set-back and the new concept of Semi-public Urban Space;
- ☐ To explore some applicable implementation systems in consideration of Land Readjustment System.




The land use within the project area is based on the BEIP Survey in September 1996

Fig. 11.7

| NAME OF THE PROJECT | DIN DAENG RENEWAL PROJECT |
|---|---|

## TARGETS OF ENVIRONMENTAL IMPROVEMENT

To make the NHA housing renewal project more functional and attractive, integrating related projects being planned in the surrounding improvement such as MRTs (Orange, Red and Blue Lines), New BMA City Hall and Makkasan Redevelopment.

## CHARACTERISTICS OF THE LOCATION

- The Project area is located in the inner city where more intensified land use is required for public services. The public sector owns most of the land, thereby easing land acquisition for the implementation.
- The NHA housing area is 23.36 ha with 22,690 population at present (931 prs/ha) and the FAR is 169%.

## PLANNING CONCEPTS

- Creation of a "New Bangkok Social Center" in association with improvement of adjacent public service facilities such as New Bangkok City Hall, government offices, the Youth Stadium, hospital and schools;
- Intensification of the housing land use to accommodate 37,000-38,000 population with a new FAR of 500-550 %, providing high-rise housing buildings;
- Environmental improvement by preparing affluent open space, pedestrian facilities, community services for elderly people;
- Formation of a Mass Transit-based transport structure with functional linkages of access roads and pedestrian paths and MRT stations as well as the feeder bus service network.

## FOR THE IMPLEMENTATION

- To formulate an overall development master plan in coordination with relevant agencies/organizations and the communities;
- To re-consider and/or coordinate the suitable locations of the stations of Orange Line in relation with the Project;
- To organize a planning committee for the Project with representatives of relevant organizations;
- To organize the resident community for well-management of environmental activities at community level.

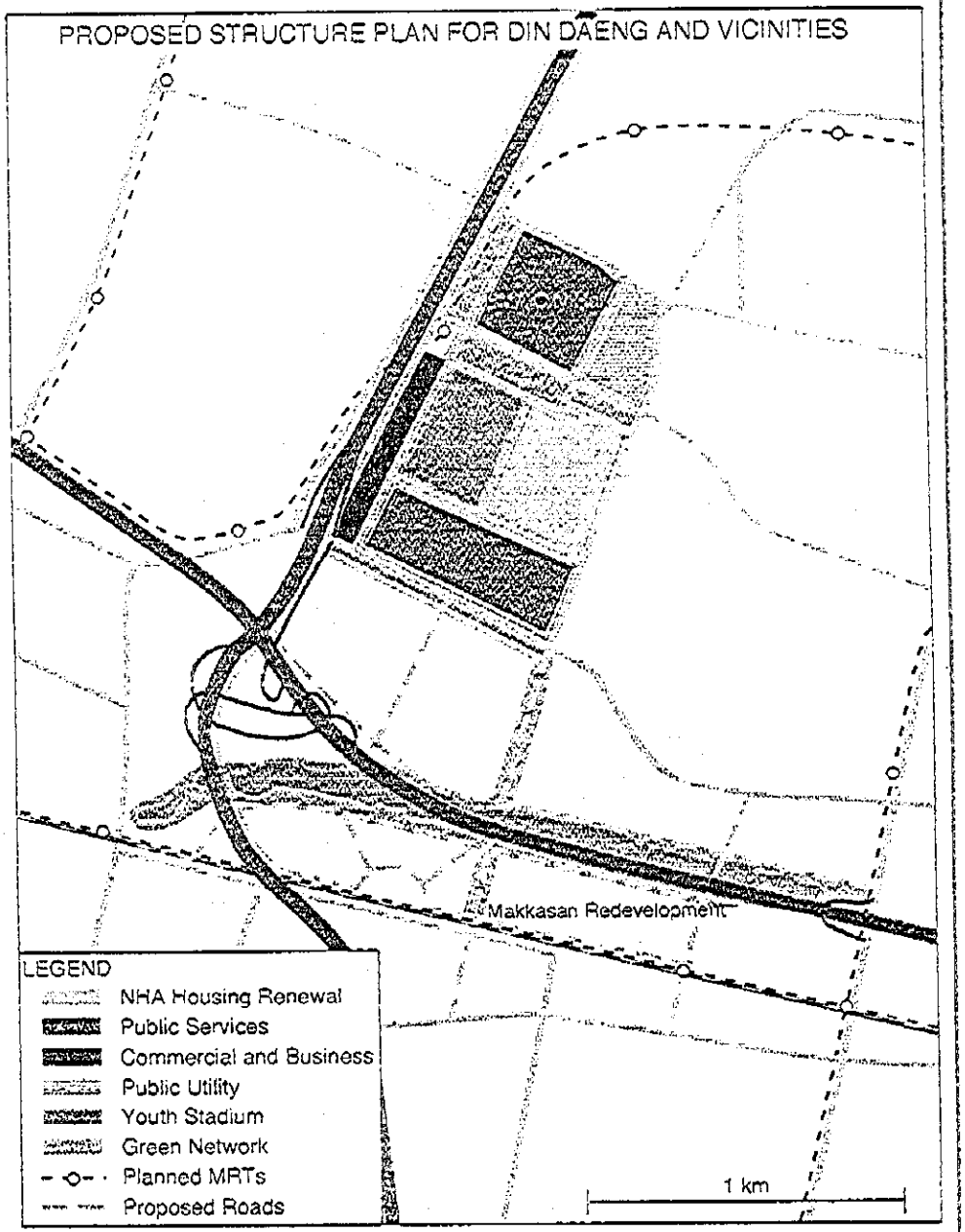


Fig. 11.8

| NAME OF THE PROJECT | CHAO PHRAYA RIVER-FRONT REDEVELOPMENT |
|---|---|

## TARGETS OF ENVIRONMENTAL IMPROVEMENT

To vitalize the land use of the Chao Phraya river-front area (parts of Bang Kho Laem, Yan Nawa and Ratburana), by facilitating relocations of warehouses and factories of which the locations are no longer functional.

## CHARACTERISTICS OF THE LOCATION

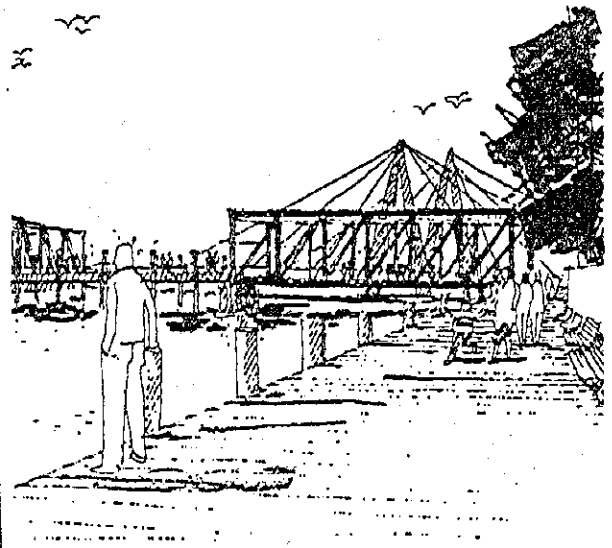
- ☐ The Project area is a strip of Chao Phraya river-front from the Rama IX bridge to the Taksin Bridge where warehouses for rice,beverage and timbers and small-scale factories are located.
- ☐ The land uses are now changing to more land-efficient type of use such as condominium, hotels, supermarkets, so on. Nevertheless, open space still remains in some parts, awaiting new development.

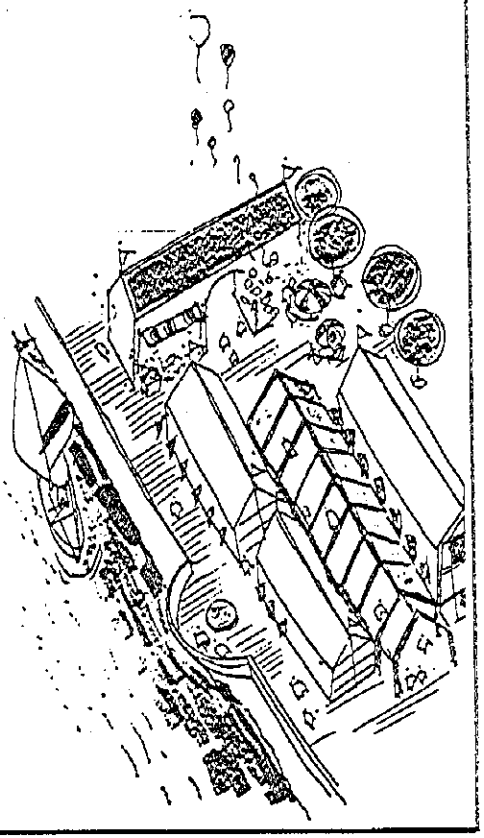
## PLANNING CONCEPTS

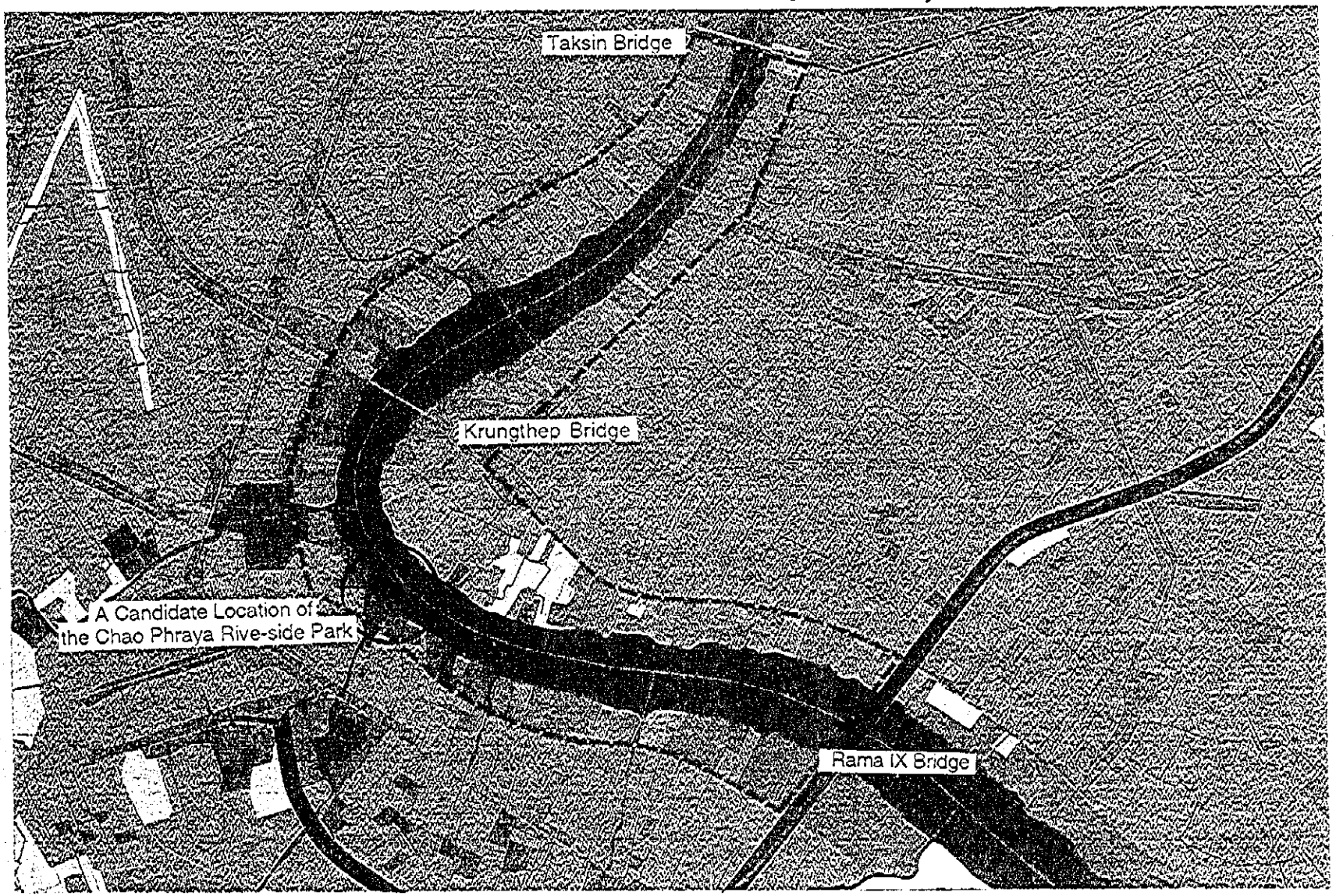
- ☐ Facilitation of relocation of the less functioning warehouses and factories, providing institutional incentives, substitutive land or compensation schemes;
- ☐ Formation of a linkage program with the relocation program and the Subcenter zone development (preparation of the land for the would-be-relocated facilities);
- ☐ Development of "Chao Phraya River-side Park" with unique landscape and water-friendly facilities for Bangkok people and tourists and develop Waterway Boat Terminal.
- ☐ Facilitation of development of Chao Phraya water management facilities;
- ☐ Preservation of the open space for the environmental purpose, through facilitation of the land purchase by the public sector.

## FOR THE IMPLEMENTATION

- ☐ To designate the Project area as the policy zoning area and conduct the survey of land tenures and facilities to seek the possibility of relocation;
- ☐ To formulate the Master Plan and Action Plans for the Project;
- ☐ To explore an institutional framework (tax incentives and compensation) to acquire the land for the public purpose;
- ☐ To organize the Chao Phraya River-side Park Development Corporation" jointly with the public and private sectors.








The land use within the project area is based on the BEIP Survey in September 1996

## Landuse in River Side

legend

- River
- High Density Residential Area
- Middle Density Residential Area
- Low Density Residential Area
- Commercial Area
- Industrial Area
- Warehouse Area
- Governmental and Public Facilities
- Open Space/Agriculture Area
- Conservation Area
- Park
- School
- Religion
- River
- Rail
- BMA Boundary
- District Boundary
- Subdistrict Boundary
- Primary Road
- Soi

Proposed Project Area

SOURCE : AERIAL PHOTOS TAKEN IN MARCH , 1995

Fig. 11.9

| NAME OF THE PROJECT | RATHANAKOSIN CONSERVATION |
|---|---|

## TARGETS OF ENVIRONMENTAL IMPROVEMENT

To form an institutional framework and propose physical improvement to conserve the historically invaluable assets and districts, while promoting the Thai unique environment.

## CHARACTERISTICS OF THE LOCATION

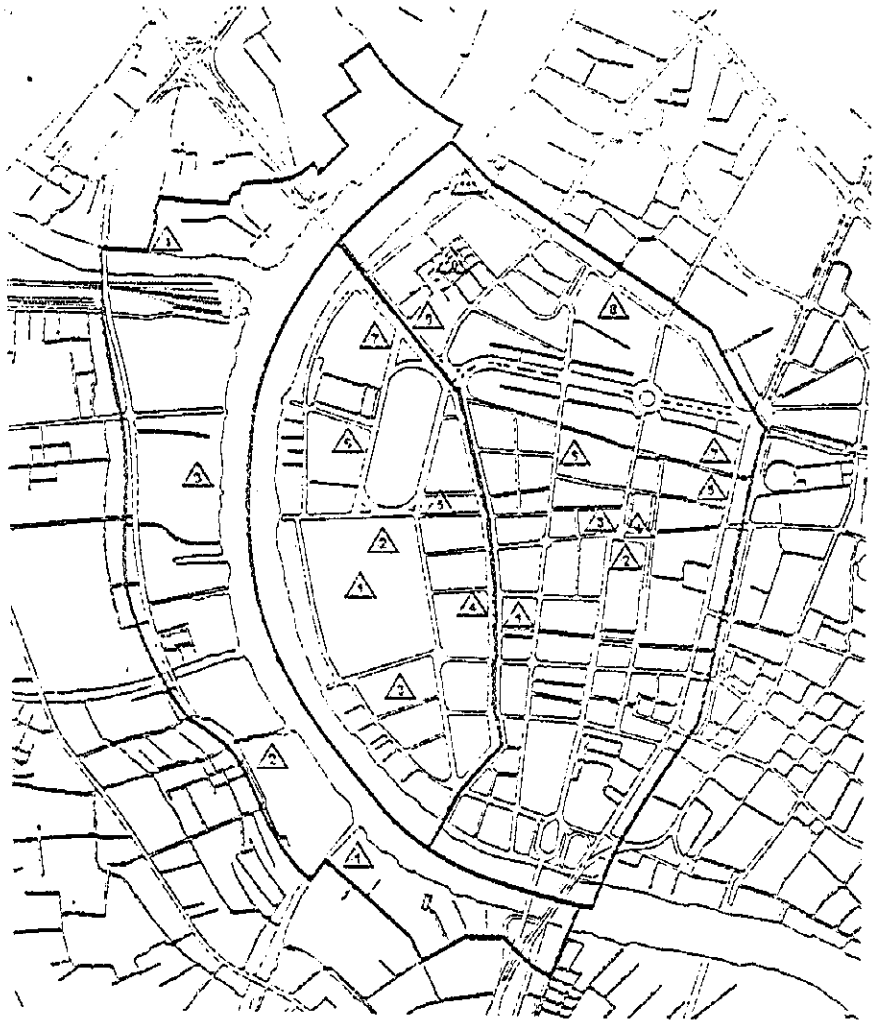
- ☐ The Project area is located in the historical center of Bangkok where is the Thai people's spiritual core.
- ☐ The area is separated in two parts alongside Chao Phraya River, and mixed with a variety of functions such as shops, business offices and houses as well as the historical facilities such as the Palace, museums, temples and government offices.

## PLANNING CONCEPTS

- ☐ Strengthening of the current institutional framework to control the private sector's activities for construction and renovation of invaluable buildings and land development;
- ☐ Expansion of the designated area based on the recommendation of the Bangkok Plan proposed by the MIT/EC group;
- ☐ Development/improvement of public parks, selected symbolic streets, landscape facilities and public markets;
- ☐ Facilitation of works for "Urban Design" with a Thai unique concept for street greening, trash boxes, public telephone booths, street benches, pocket parks and so on in the specially designated areas.

## FOR THE IMPLEMENTATION

- ☐ To formulate Action Plans to materialize the conservation policies emphasized by the National Committee and by 5th BMA Development Plan;
- ☐ To organize the Joint Rathanakosin Design Committee with representatives from the communities to promote people's participation in the implementation of planned projects;
- ☐ To arrange the Special Rathanakosin Fund for the planned conservation works.



DESIGNATED RATHANAKOSIN HISTORICAL CONSERVATION AREA

# CHAPTER 12: APPLICATION OF GIS TECHNIQUE FOR PLANNING

## 12.1 Introduction to GIS

It is needless to say that huge amount of geographic data will be collected, analyzed, and evaluated at the planning works of any regional/urban development or environmental management projects. Recently, GIS (Geographic Information System) technique which had initially developed and put into market place in early 1980's in USA has been widely applied to the spatial data digitization, analysis, and mapping for various spatial development/management projects in the world. At the initial stage of software development and diffusion of the GIS, cost performance of this system was still in low efficiency, however, because of the recent innovative progress of computer technology, efficiency of data processing is largely improved and packaged system of GIS has been easily installed and used by many users.

In this study, ARC/INFO as the most updated and world standard software of GIS and related computer system (EWS) has installed in the project office to support the planning works. Based on this system, geographic database for the BEIP study has been constructed. As a result of the data manipulation and processing, various type of maps and tables were displayed in the previous chapter of this report. These maps and tables are showing not only the existing environmental conditions of the study area but also the planning indicators of the BMA.

Since the GIS was developed in early 1980s, the spatial analysis in urban or regional development planning has been one of the most effective and cost efficient applications in GIS technology. For a long time, regional planning works have been conducted by manual systems, with records on paper and mylar. Planning works, by its nature as an information-rich discipline, has much to gain from the facilities which the new technology provides. Information organized with GIS therefore provides a framework to support the process of decision making which together constitute planning practice.

Environment is also a great concern in the field of GIS application. One main reason for this is the need to compare a great number of area-related data describing the natural resources involved and their sensitivity to the effects of various impacts. Because GIS can be used to couple area-related data with their attributes, and can be used to overlay these, they represent highly efficient instruments for such planning tasks.

Nowadays, GIS becomes a common tool for all who need to analyze spatial data according to their specified purpose. The growth in GIS technology has been spreading wide and rapidly to not only planning works but wide range of application of physical resource management , environmental assessment and so on.

This technical note describes the contents of BEIP-GIS and points out the several problems as well as necessary measures to be taken for the introduction and application of GIS for the coming information oriented society of the Thailand.

## 12.2 Concept of the Urban Environmental Information System

The GIS applied in the BEIP study is called as Environmental Information System (EIS), that is specially designed to support the urban land use planning and environmental management for the area of Bangkok Metropolitan Administration(BMA). As illustrated in Fig. 12.1, EIS is a system that incorporates and integrates the functional sub-system of urban planning, transport planning and environmental planning. The functionality and activities associated with each sub-system are needed to define in terms of GIS performance.

### (1) Urban Planning Sub-system

This sub-system aims at creating the alternative land use plan by projecting various environmental factors onto the real world, and contributing to the actual urban planning works. Many kind of map data which represent existing urban condition of the BMA and socio-economic statistical data are digitized and stored into the computer as a geographic database. Based on this database, spatial distribution of physical constraints, land use suitability, and future urban development potentiality are analyzed and mapped.

### (2) Transport Planning Sub-system

This sub-system aims at creating the alternative transport plan by simulating the traffic volume and congestion based on the existing and planned road networks. For the transport planning, TRANPLAN software was used to analyze existing and future traffic condition. BEIP-GIS supply the basic information on road network, traffic analysis zone(TAZ), and related data. After the necessary data analysis by TRANPLAN, final results were transferred to GIS again and mapped.

### (3) Environmental Planning Sub-system

This sub-system aims at creating the alternative environmental management plan by simulating the air, water quality and noise conditions using each environmental mathematical model.

The functionality of the total system can be divided into the following six main elements from which A, D, E and F are directly related to the use of GIS.

(A) Data entry, storage, retrieval and management;
(B) Computation of traffic volume by simulation model;
(C) Computation of Air pollution by emission model;
(D) Spatial (land use) and environmental analysis;
(E) Comparison and evaluation of alternatives;
(F) Presentation and mapping; and
(G) User interface and scenario generator.

The system was designed based on the clear-cut identification of objectives and needs for the analysis. The following attention was paid on the process of database development.

- Examination of data availability in terms of its accuracy, source, method and date of data generation;
- Collection of existing data files in the form of M/T or F/D or M/O to avoid the duplication of data input;
- Examination of model development in GIS in close collaboration with relevant agencies;
- Preparation of output images linked with input from the database
- Examination of the most appropriate system for EIS based on the data volume, input format, output map production, CPU performance, disk capacity and type of package software of GIS; and
- Examination of system compatibility, availability of local system support and maintenance services.

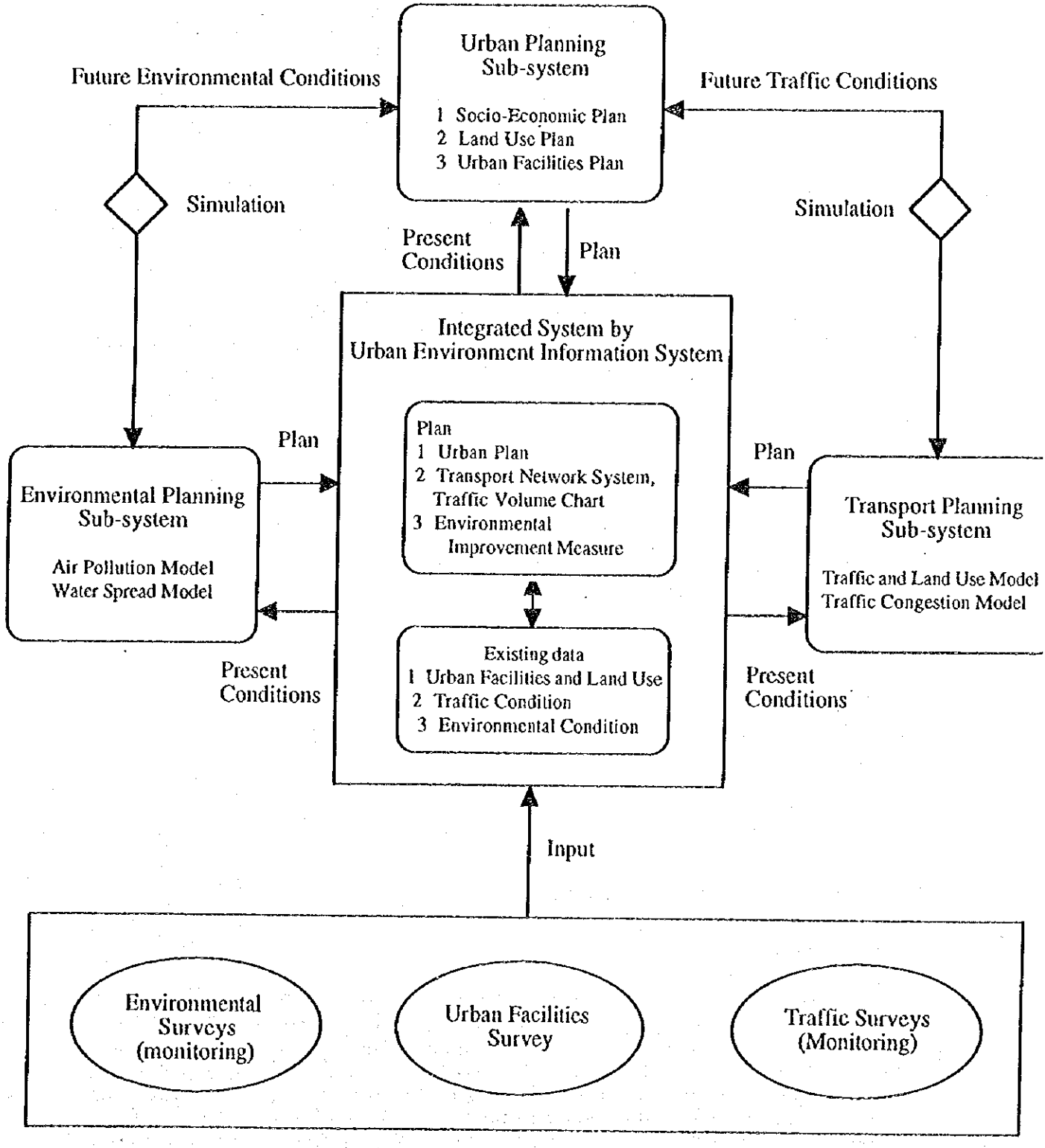



**Fig. 12.1 Concept of Urban Environmental Information System**

## 12.3 System Configuration

The typical hardware configuration for GIS comprises a central computer surrounded by memory and storage disks and a number of peripheral devices. Time sharing system is also important because it enables terminal units with lines attached to the central computer to be used at the same time. Like every other computerized information system, GIS are comprised of the integration of hardware and software packages.

Hardware configuration is usually designed considering the software performance that runs on the machine. More recently, the Engineering Work Station (EWS) has becoming an important role in the graphic oriented system such as GIS, so it is the most widely configured in many GIS vendors. For the purpose of developing large scale database, the necessity for the CPU performance and disk storage capacity is carefully examined so as to optimize the GIS software capabilities.

In the history of GIS software development, the most significant advance was the introduction of the concept of the relational database that allows linking graphic data with attributes data by the use of common key fields. The software is also required to perform certain analytical tasks according to the nature of the problems. The overlay procedure, for example, has been commonly used for combining different data sets in order to identify the problem areas or sites with required characteristics. Buffering, address matching and network analysis are additional tools adopted in the planning applications of GIS. The above functionalities are necessary to be included in the GIS software for BEIP. Nowadays, a variety of GIS products have arrived on the market and users have begun to gain familiarity with these new systems even in Thailand. In addition, local supports and maintenance services are also taken into the consideration. As the result of the scrupulous survey under the local circumstances in Thailand, the following system was finally selected.

### (1) Hardware

EWS : SUN SPARC station 20 (64 Mbyte Main Memory, 2.1Gbyte Hard Disk)
Printer : HP Laserjet 5P (A4 size)
Plotter : HP Designjet 750C (A0 size, 16 millions different color)
Digitizer :CALCOMP 34480 (A0 size, 16 Button Carsol)

### (2) Software

SUN OS, Solaris Ver. 2.4
ARC/INFO Ver. 7.0.3
CORE module
GRID module
NETWORK module
ARCVIEW Ver. 2.0

The system configuration is shown in Figure 12.2.

## 12.4 Data/Information Filed in GIS

For the purpose of developing an integrated database, plenty of data (both graphical and statistical) have been aggressively collected from various relevant agencies. The collected data are listed in Table 12.1. However, problems with data were serious because their date of compilation, accuracy, scale and format vary each other, so it would put us in a difficult situation to integrate them into a database. Because of this, it was a critical necessity to decide a base map for the data digitization, and finally the topographic maps at a scale of 1:20,000 produced by Royal Thai Survey Department (RTSD) were applied as a planimetric base map for the BEIP.

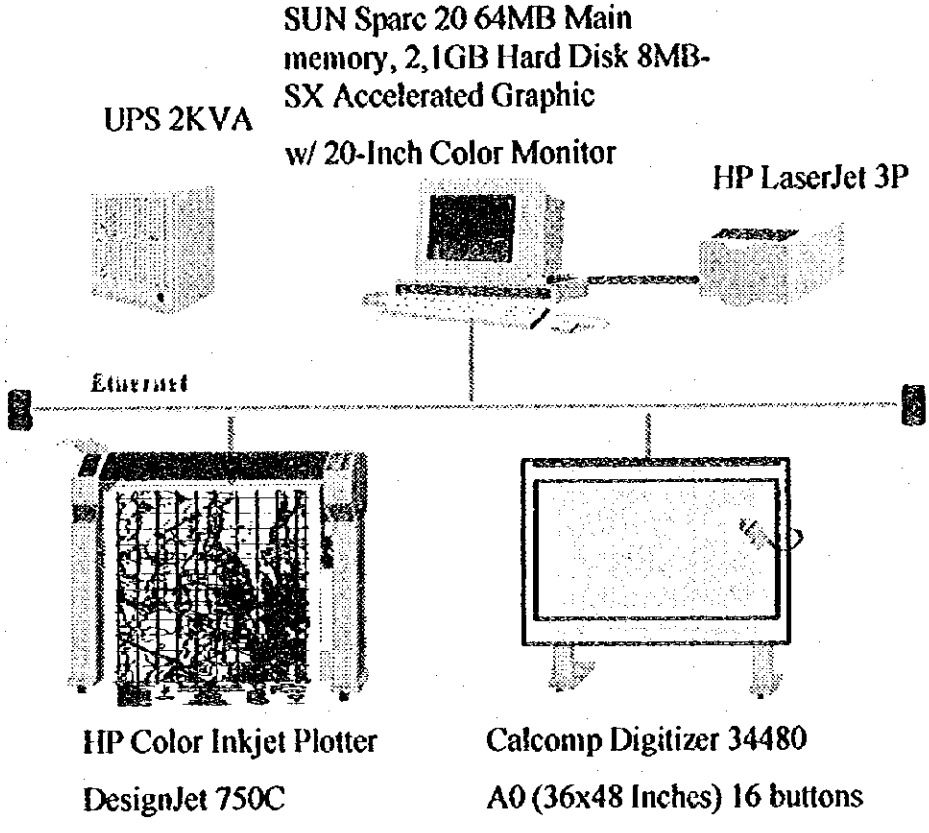



**Fig. 12.2 System Configuration**

The study area, Bangkok Metropolitan Administration(BMA) is about 1,600 square km and almost covered by 20 (twenty) sheets of the above topographic maps, but some eastern and southern tips of BMA (Nong Chok and Bang Kun Thian districts ) are missing on this map series. Topographic maps at a scale 1:50,000 (by RTSD) were supplementary used to fill up such areas as well as covering whole Bangkok Metropolitan Region (BMR). These topographical maps were finally merged each other and compiled into one map sheet scaled at 1:75,000 as a base map for BEIP study.

The status of existing roads, railways, rivers and canals, landmarks, and administrative boundaries were principally derived from the above topographic maps, however, some were lack in details or needed to be updated.

## Table 12.1 List of Map Data used for the EIS Development

| | Source map | Source | Scale | Date | Information | Remarks |
|---|---|---|---|---|---|---|
| 1 | Topographic maps | Royal Thai Survey Dept. | 1:20,000 | 1982 - 1992 | Road,Rail,River,Canal, Landmark | 20 map sheets for BMA |
| 2 | Topographic maps | Royal Thai Survey Dept. | 1:50,000 | 1970s - 1980s | Road, Administrative boundaries | |
| 3 | Administrative boundaries map | Policy and Planning Dept, BMA | 1:50,000 | 1994 | Administrative boundaries | Used for the updated 131 sub-districts identification |
| 4 | Land use map | City Planning Dept, BMA | 1:40,000 | 1993 | Land use | Not published draft map based on photo interpretation |
| 5 | Land use zoning map | Dept. of City and Country Planning | 1:75,000 | 1992 | Land use zoning | |
| 6 | Ground subsidence map | JICA report | about 1:500,000 | 1995 | Simulated ground subsidence | |
| 7 | Inundated area map (1983) | JICA report | about 1:500,000 | 1985 | Inundated area by 1983 flood | No geographic coordinate |
| 8 | Inundated area map (1995) | Dept. of Drainage and Sewerage | about 1:100,000 | 1996 | Inundated area by 1995 flood | |
| 9 | Flood protection facilities map | Dept. of Drainage and Sewerage | 1:100,000 | 1996 | Dikes, Gates, Pump Station | |
| 10 | Water service area map | Metropolitan Water Works Authority | 1:100,000 | 1995 | Current water service area Water transmission system | |
| 11 | Sewerage zone map | PCD report | about 1:500,000 | 1993 | Proposed division of sewage area | No geographic coordinate |
| 12 | Traffic Analysis Zone Map | UTDM | digital | 1995 | Traffic Analysis Zone (TAZ) | Derived from MAPINFO |
| 13 | Mass transit map | SRT, OTSC, MRTA | - | 1996 | Each agency 's plans | Not based on maps |
| 14 | Road projects map by the year 2000 (8th Plan Projects) | BMA, DOH, PWD, ETA | - | 1996 | Each agency 's plan for the 8th Plan | Some projects are still under consideration by OCMRT |

In such cases, the best efforts were made so as to look for the latest data or information in the authorized agencies. For example, the sub-district boundary is important because it composes a minimum statistical unit in BMA, so the updated and authorized administrative boundaries map which was prepared by Department of Policy and Planning, BMA was collected and digitized. The corresponding basic statistics such as demography were collected at the National Statistics Office and UTDM.

On the other hand, a lot of thematic maps were also gathered from various agencies in and out of BMA, and they are largely divided into the following 4 (four) thematic groups.

- Land resources and conditions, land use, land status,
- Physical constraint, flood area, land subsidence
- Environmental issues, water quality, air pollution, traffic volume
- Social infrastructures, transportation, water service, sewage

The problem at this stage is that these maps are different in date of compilation, scale, accuracy and format and so on because they have not been produced based on the same national base map. It is of primary importance to keep the coordinate accuracy of each map if it will be stored in a sophisticate database. Otherwise, GIS cannot perform any spatial analysis such as overlaying in the next stage.

For this purpose, all thematic maps collected at different agencies are needed to be transferred onto the base map for the preparation of digitization.

Geographical Information System (GIS) is well known for its capability to store both graphical and statistical data at the same time and place. Database Management System (DBMS), one of the most significant advances in GIS software, introduced the concept of the relational database. It serves the very important function of storing very large quantities of information, easily inquiring them, and performing various geographic data manipulation and analysis. In this project, INFO that is the relational DBMS of ARC/INFO is applied to handle basic storage, management and analysis operations for geographic data.

Prior to the data digitization, as described before, all thematic map boundaries were transferred onto a base map (scale 1:75,000) so as to uniform the coordinate control points (TICs), then set on a digitizer. ARC/INFO Ver.7.0.3 was used for all the process of data input, edit, encode and check plots. Statistical information were also stored in conjunction with each statistical unit of maps, especially administrative boundaries map comprised of 151 (one hundred fifty one) sub-districts are frequently used and connected with a lot of attributes data. The contents of the geographic database for BEIP are listed in the followings.

**(1) Administrative Boundaries (BMA)**

1) Map Data Dource

Topographic maps (1:20,000, partially 1:50,000)

2) Attributes (sub-district base)

Province name in Thai and English
District name in Thai and English
Sub-district name in Thai and English
Sub-district code
Area (square km)
Build-up area (square km)
Build-up ratio (%)
Open space ratio (%)
Population in 1995
Household in 1995
Gross population density in 1995
Net population density in 1995
Population in 1990
Household in 1990
Population increase rate (%) between 1990 and 1995
Gross road density (m/ha)
Net road density (m/h)
Soi rate (%)

**(2) Administrative Boundaries (BMR)**

1) Map Data Source

Topographic map (1:50,000)

2) Attributes

Province name in Thai and English
District name in Thai and English
Sub-district name in Thai and English

**(3) Existing Land Use**

1) Map Data Source

land use map (1:40,000) based on the interpretation of aerial photos (1993)

2) Attributes

0 Water bodies
1 High density residential area
2 Middle density residential area
3 Low density residential area
4 Commercial area
5 Industrial area
6 Warehouse

7 Governmental facilities area
8 Agriculture / Open space area
9 Conservation area
10 Park
11 School
12 Religion

**(4) Road, Hydrology, Rail (SRT)**

1) Map Data Source

Topographic map (1:20,000)

2) Attributes

Road
Road length (m)
Road class (derived from the legend of the topographic map)
1 Primary road
2 Secondary road
3 Through road
4 Soi
5 Express road with Thai name
Hydrology
No attribute
Rail
Station name

**(5) Landmarks**

1) MapDdata Source

Topographic map (1:20,000)

2) Attributes

Landmark type
31 School
32 Church
33 Temple
34 Mosque
35 Ministry
36 District office
37 Police station
38 Embassy
39 Consulate
40 Hospital
41 Bank
42 Factory
43 Hotel
44 Governmental agencies name in Thai

**(6) Inundated Area by 1983 flood**

1) Map Data Source

Derived from existing report by JICA

2) Attributes

Inundated area (square km)
Inundated type
1 Inundated
2 Not inundated

**(7) Inundated Area by 1995 flood**

1) Map Data Source

Derived from existing report by DDS

2) Attributes

Inundated type
- 1 Inundated
- 2 Not inundated

**(8) Simulated Land subsidence**

1) Map Data Source

Derived from existing report by JICA (1995)

2) Attributes

Simulated subsidence class
- 1 Less than -50 cm
- 2 -51 to -75 cm
- 3 -76 to -100 cm
- 4 -101 to -125 cm
- 5 -126 to -150 cm
- 6 More than -151 cm

**(9) Traffic Analysis Zone (TAZ)**

1) Map Data Source

Originally produced by BEIP based on the topographic maps (1:20,000)

2) Attributes

Zone number
Zone area (square km)
Land use type
- 2 CBD
- 3 China town
- 4 Urban
- 5 Sub-urban
- 6 Rural

**(10) Land Use Zoning System**

1) Map Data Source

Land use zoning system map

2) Attributes

Land use zoning type
- 0 Water bodies
- 1 Low density residential area
- 2 Middle density residential area
- 3 Low density residential area
- 4 Commercial area
- 5 Industrial area / Warehouse
- 6 Warehouse
- 7 Special industrial area
- 8 Agriculture
- 9 Recreational / Open space
- 10 Educational institute

11 Rural agriculture Conservation
12 Conservation for Thai culture
13 Religion
14 Governmental office / Public facilities

**(11) Sewage Zone**

1) Map Data Source

Originally produced by BEIP based on the topographic maps (1:20,000)

2) Attributes

Sewage zone number
Sewage zone area (square km)
Operation stage
1 Under operation
2 Under planning
3 Expansion plan

**(12) MWA Water Service Area (BMA and BMR)**

1) Map Data Source

MWA water service area map

2) Attributes

Zone name
1 Bang Bua Thong
2 Bangkhaen 1
3 Bangkhaen 2
4 Bangkok Noi
5 Mansri
6 Minburi
7 Nonthaburi 1
8 Nonthaburi 2
9 Phasicharoen
10 Phaya Thai
11 Phrakanong - Bnagna
12 Samut Prakarn
13 Sukhumvit - Pattankarn
14 Taksin 1
15 Taksin 2
16 Thung Mahamek
Service stage
1 Service area
2 No service area
Water service area expansion plan
1 Water service area in 1995
2 Water service area before 1997/1
3 Water service area before 1997/2
4 Water service area before 2007
5 Water service area before 2017

**(13) BOD Loading Investigation / Water Quality Sampling points**

1) Map Data Source

Originally produced in BEIP study based on topographic map (1:20,000)

2) Attributes

Origin type
- 1 Latkrabang industrial estate
- 2 Hotel
- 3 Hospital
- 4 Condominium
- 5 Restaurant
- 6 Private office
- 7 Department store
- 8 Fresh food market
- 101 Mixed area I : Democratic Monument
- 102 Mixed area II : Phatpong
- 103 Mixed area III : Wong Wain Yai
- 11 Residential area (NHA)
- 12 Residential area (town house)
- 13 Residential area (single house)
- 14 School

Sampling point number

**(14) Khlong Water Quality Sampling Point and BOD**

1) Map Data Dource

Originally produced in BEIP study based on topographic map (1:20,000)

2) Attributes

Sampling type
- 1 Existing
- 2 Existing new
- 3 New

Water quality
- 1 More than 40
- 2 30 to 39
- 3 20 to 29
- 4 Less than 20

Sampling point number

**(15) Flood Prevention and Drainage Facilities**

1) Map Data Source

Originally produced by BEIP based on the topographic maps (1:20,000)

2) Attributes

Protection stage
- 0 No protected
- 1 Protected drainage pump station point

Water gate point

**(16) Mass Transit Plan (including SRT Rail Project)**

1) Map Data Source

Originally produced by BEIP based on the topographic maps (1:20,000)

2) Attributes

Project type
- 1 BTSC - green
- 2 MRTA - blue
- 3 MRTA - orange

4 MRTA - purple
5 MRTA - red
11 BTSC - green (ext)
12 MRTA - blue (ext)
13 MRTA - orange (ext)
15 MRTA - red (ext)

Project stage
1 On going
2 Proposed

Station plan

**(17) Road Project**

1) MapData Source

Major BMA road projects in 8th plan, DOH project, PWD project

2) Attributes

Plan type (BMA)
Year 1995 0 improved existing road
Plan 2000 1 new road
Road ID

Plan type (DOH)
Year 1995 0 improved existing road
Plan 2000 1 new road
Road ID

Plan type (PWD)
Year 1995 0 improved existing road
Year 2000 1 new road

**(18) Boat/Ferry Service**

1) Map Data Source

Originally produced by BEIP based on the topographic maps (1:20,000)

2) Attributes

Ferry pier point
Service type
1 Khlong express boat service
2 Chao Phraya river express boat service
3 Chao Phraya river crossing boat service
Pier name (service type 2 only)
Service line (service type 3 only)

**(19) Road Network from TRANPLAN Data**

1) Map Data Source

Originally produced by BEIP based on the topographic maps (1:20,000 and 1:50,000)

2) Attributes

Road traffic volume (daily base)
Road traffic volume (peak hours base)
Travel speed distribution (peak hours base)
Level of service (peak hours base)
Number of traffic lanes
Number of Bus lanes

**(20) Person Trip OD**

1) Map Data Source

Originally produced by BEIP based on the topographic maps (1:20,000)

2) Attributes

Daily base
Peak hours base

**(21) The Bangkok Plan (draft), DCP, BMA**

1) Map Data Source

The Bangkok Plan report

2) Attributes

Land use type
1 Residential area
2 Commercial area
3 Industrial area
4 Agriculture
5 Park
6 Mixed use

Maximum allowable FARs (FAR type)
1 10:1
2 6:1
3 4:1
4 2:1
5 1:1
6 Rural

**(22) Khlong Water Quality Improvement (East Bank), DDS, BMA**

1) Map Data Source

Originally produced by BEIP based on the topographic maps (1:20,000)

2) Attributes

Boundary of water dilution system
Dilution water intake station
Dilution water discharge station
Dilution water intake and discharge station
Direct aeration site
Khlongs for direct aeration site 5
Khlongs for dredging work
Khlongs for construction of retaining wall