

CHAPTER 5

DEVELOPMENT PLANS FOR NATURAL RESOURCES AND INFRASTRUCTURE

5.1 Land and Environment

5.1.1 Objectives and strategy

(1) Environmental constraints

Major constraints to development related to environment consist of present land use and ownership patterns, soil conditions, water quality and flooding as summarized below. Problems of urban environment are discussed in Section 5.6.

Land use and ownership

The land capability analysis has revealed that there is considerable mismatch between the present and the potential land use (subsection 3.3.4). To secure reasonable coverage of forest area, the existing conservation forest area should be protected and part of the field and tree crop area and the development area should be devoted to economic forests in addition to the reforestation area. Under these conditions, the land use for agriculture would be constrained by the rate of land use conversion from the present use to the potential use.

As already described, the land ownership security is another constraint to development (subsection 4.1.1). Insecure land tenancy discourages investments to improve land productivity.

Soil conditions

Distribution of problem soil has been analyzed by a GIS with the following results. Acid sulphate soil is present in Nakhon Nayok covering 108,400 ha and in Prachin Buri covering 35,000 ha. The land of this soil is predominantly used for paddy cultivation. Saline soil areas are found mainly in Nakhon Ratchasima with 63,900 ha and Surin with 16,500 ha, and used mainly for paddy. Sandy soil areas are widespread in Ubon Ratchathani (251,200 ha), Si Sa Ket (85,500 ha), and Nakhon Ratchasima (59,100 ha). The large areas in Ubon Ratchathani and Si Sa Ket are mostly used for paddy, despite their severe limitations for this crop. Skeletal soil areas are particularly large in Prachin Buri (175,900 ha) and Nakhon Ratchasima (158,000 ha), and used mainly for field crops. Skeletal soil is characterized by the occurrence of laterite or gravel layer at shallow depth which interferes with elongation of roots and causes difficulties in ploughing.

One third of the Study Area is classified under erosion hazard soil. In the Northeast, severe erosion can take place even in gently sloping plateau due to soil characteristics, poor in stable aggregates and structureless. Selective erosion is also widely observed in the plateau, in which clay and organic matters are removed selectively from soil by washing. This type of erosion is seen widely in paddy soil areas and particularly severely in salt-affected area in the Study Area.

Water quality

NEB has been conducting water quality surveys in major rivers in the Study Area, and established quality standards for five classes. The Nakhon Nayok river is classified as class 3 suitable for consumption after ordinary water treatment and applicable directly for irrigation. The Prachin Buri river is cleaner and of class 2 suited also for aquatic organism conservation and tourism. However, the total coliform count has been increasing for both rivers in recent years, indicating increasing domestic waste discharges.

Most stretches of the Mun river can be classified under class 2 or 3. Fecal coliform numbers are higher and the dissolved oxygen lower at stations in and near the Nakhon Ratchasima city. BOD measurements are larger at stations located at small towns.

The water quality of the Chi river within the Study Area corresponds largely to class 3. An exception is at the Yasothon city, where BOD measurement is higher and the total coliform count larger.

Flooding

Flooding during the wet season is habitual for the Mun and the Chi rivers. This is caused by very slow runoff and high water in the Mekong river. Flooding problems are persistent particularly in Yasothon.

Flooding in Prachin Buri is due to large catchment area and very heavy rainfalls on the northern slope of the drainage area. Flooding in Nakhon Nayok is of flush flood type, and backwater effects of the main Bang Pakong river tends to aggravate the effects. The sea water intrusion up the Bang Pakong river often goes beyond the confluence and up the Nakhon Nayok river.

(2) Objectives

Objectives for development and conservation of land and environment are set as follows to support the LNE-UE regional development objectives.

- 1) To enhance the overall land productivity to support higher level of primary production through land use conversion, land tenancy improvement and proper land management for agriculture;
- 2) To improve the water environment for physical and moral sanitation of local people through further water resources development, better on-farm water management, and treatment of domestic and industrial wastewater; and
- 3) To promote people's consciousness to environmental quality through their participation in water-saving and soil-improving development activities as well as education.

(3) Strategy

Land use control

Resolution of emerging conflicts over land use and realization of potential land use identified call for the following strategy. The enforcement of land policy with the clarification of land use and improved land ownership security is the priority to resolve conflicts in land use between forestation and agriculture. To avoid conversion of prime agricultural land to urbanization/industrialization, urban land development plans should be prepared and enforced for fast growing urban centers. An example is Prachin Buri where more industrialization may be encouraged by relocation of industries from the BMA, as it does not share the catchment area with the BMA.

Forest protection and reforestation

For the preservation of existing forests, a buffer zone of about 5 km width may be defined around the protected area. Villagers in villages within this buffer zone should be actively involved, given a leading role in protecting the adjacent forests. For active promotion of the economic forests, various kinds of economic forestry programs should be initiated by the participatory approach. Local people should be involved from an early stage of program formulation. Also on-farm tree planting by individual farmers should be encouraged through education to farmers for economic utility of planting a hedge with energy crop or soil enriching crop such as leucaena, and supply of seedlings/saplings with technical information.

Soil management

The soil in the Study Area is generally low in fertility and water retention capacity. This calls for more cautious approach to increasing the use of agro-chemicals to enhance land productivity. Applied chemicals would find easier way to groundwater and in turn surface water.

Better options would be the improved management of land use as well as the application of organic fertilizer. Increased area under managed pasture, second crops and properly rotating crops would not only enhance the land productivity but also help to reduce soil erosion. The proper crop rotation would help to maintain/recover soil fertility and water holding capacity, and prevent certain crop diseases to develop. Priority for applied research needs to be geared more to establishing such crop rotations.

Water resources management

Most efforts to supply irrigation water in the past were made by a piecemeal approach. Small irrigation facilities to meet immediate irrigation needs, usually in their immediate vicinity, were not planned well with respect to their location and size. To meet growing water demand for industrialization and irrigation as well as domestic use, multi-purpose water resources development is recommended. A river basin approach should be taken to plan for integrated water facilities (Section 5.2). This would provide an opportunity to organize farmers to manage these integrated facilities.

5.1.2 Development targets

Development targets related to future land use are given in subsection 3.3.4. Forestation targets consist of the protection of existing forest areas comprising 17.7% of the Study Area, the reforestation area (4.9%), and economic forest areas allocated from the field and tree crop area (5%) and the development area (5%). The total forest coverage should exceed 30% of the Study Area by 2010.

A minimum target for water quality should be the maintenance of the status quo water quality in the major rivers. To attain this, wastewater treatment systems need to be introduced/expanded for selected urban centers (e.g. Nakhon Ratchasima and Yasothon), and industrial effluents from large industries, existing and new, should be separately treated.

For most aspects of environment, setting specific development targets may not be meaningful without any solid basis. Rather, monitoring would be appropriate to collect data systematically and take corrective measures as adverse effects are observed.

5.1.3 Development projects and support measures

(1) Problem soil management and soil erosion control

This will involve the preparation of problem soil inventory and maps, comprehensive review of earlier studies, formulation of strategy, and establishment of pilot projects covering all different types of problem soil.

(2) Fragrant wood afforestation program

This project will establish tree species of fragrant wood suited to water and soil conditions in the Study Area. A focus will be on reforestation areas in the provinces of Buri Ram, Surin, Si Sa Ket and Yasothon. The project will involve a feasibility study to examine international market prospects of fragrant wood, identify areas for pilot implementation and formulate a comprehensive implementation program with active local participation.

(3) Regional environmental monitoring

This project will establish a regional environmental monitoring and evaluation system for the LNE-UE regions with a database using GIS. The database will provide a common basis for carrying out EIAs of individual projects.

(4) Economic reforestation program

This project covering all the provinces is to achieve reforestation with multiple objectives. Supplying agro-industrial needs (eucalyptus plantations for paper and pulp industry), fuelwood needs of the general population and other community needs for wood would be primary objectives. The project serves for prevention of further encroachment of protected forests and also will generate considerable income generating job opportunities.

Thailand has considerable experience in commercial plantation forestry and social forestry, and some studies within the Study Area are also available. A comprehensive

review of previous studies will be done and sub-projects formulated. This project will also serve to tackle the social environmental problem related to occupancy of national forest reserves and will adopt a participatory approach with active involvement of local communities and NGO groups to work in cooperation with government agencies. Forestry villages will be established. The fragrant wood afforestation program described above could eventually be a sub-project under this project.

(5) Protected area buffer zone program

Around the protected areas identified, a buffer zone of about 5 km width will be established by legislation. Roles and responsibilities of government agencies and local communities in the buffer zones will be defined with the primary aim of preventing any further encroachment or degradation of adjacent protected areas. Land use within the buffer zones will be determined and controlled.

(6) Land information system development

Once a national land policy is defined, accurate up-to-date land information is essential for land use planning. A land information system (LIS) should be established containing size, boundaries, areas, use, physiographic conditions, soil properties, water resources, names and address of land holders, value and others. The LIS would facilitate the use of information to analyze problems, make assessment and reflect it in specific land policy measures. The LIS system would be made up of various sub-systems such as base maps, public utility data base, land ownership data base, property value data base, natural resources data base, socio-economic data base and other use specific data bases. This project will formulate the structure of the LIS and prepare a plan to develop the LIS for the Study Area. One of the provinces will be selected for a demonstration project to formulate the LIS in detail and implement it.

5.2 Water Resources

5.2.1 Objectives and strategy

(1) Characteristics of LNE-UE water situation

The water situation in the Study Area (LNE-UE) seem almost dismal. Access to improved water supply is assured for only 5% of the people in the Study Area as far as PWA facilities are concerned, while this ratio is over 15% nation-wide. Of the total households in the seven Study Area provinces in the Northeast, 40% are suffering from acute shortages of drinking water.

Solving these problems would by no means be an easy task, given the natural conditions in the Study Area. Distribution of rainfall is uneven especially in the Lower Northeast where more or less 90% of the total annual precipitation concentrates in the rainy season of May through October. Value of run-off coefficient is very low with the average of some 0.2. Groundwater is often salty in the northern part of the Study Area. Generally flat terrains and soil of low water retention capacity make water storage ineffective.

(2) Objectives

Water is critically important for the development of the Study Area as indicated by the characterization above. Objectives for water resources development, therefore, have direct bearings on the LNE-UE regional development objectives.

- 1) To expand substantially the supply of water to support industries and other urban activities and to develop appropriate sources of water to assure decent quality of rural life;
- 2) To develop water resources in selected localities where irrigation and/or tourism potentials are superior to enhance the quality of land and water environment; and
- 3) To promote people's participation in water resources development and management for efficient use of limited water resources.

(3) Strategy

Given the characteristics of water situation in the Study Area outlined above, the strategy for water resources development consists of a few components. One is to store rain water when available by storage reservoirs or water jars. Another is to explore more sources of water, typically groundwater. Still another is to formulate multipurpose water resources development projects to allow efficient use of these limited resources. These components are described below.

Storage reservoirs

Storage of rain water in lowland area is not generally an efficient option, especially when it is in the form of unconnected irrigation ditches and ponds, as widely practiced in the Study Area. This is because water surface area tends to be large with small depth to increase evaporation, and water would have to be pumped up to serve an extensive area. When water is stored in unconnected irrigation ditches, surface water run-offs are reduced to make less water available for further downstream.

In order to rectify the situation, water storage and regulating facilities, small and large, should be inter-connected as much as possible. This would call for two conditions to be satisfied. First, better planning of those facilities would be necessary to begin with from a viewpoint of larger areas, ideally entire river basins or sub-basins. Second, proper arrangements would have to be worked out for the management of the integrated facilities.

Water jars

Water jars provide effective means to store small amount of water for individual household use. For an average household with 4.0 family members, the storage of 10 m³ would cover the water use for three months, if the minimum per capita use of 25 litre per day is assumed. This would help to bridge the water availability gap due to extended drought. Three to five water jars of larger size per household would satisfy this requirement, while the average number of water jars per household is less than two at present.

Groundwater exploration

Use of groundwater will continue to be important particularly for drinking water supply in rural areas not served by rivers or storage reservoirs. Groundwater exploration should be intensified in more promising areas identified by DMR. More promising areas in the Study Area may be found on the southern slope of the Mun river and in the middle to the upper catchment area of the Bang Pakong river in Prachin Buri.

Multi-purpose water resources development

To make an effective use of limited water resources, multi-purpose water resources development should be carried out from a viewpoint of river basins/sub-basins. Priority for multi-purpose reservoirs should in general be given to flood control and water supply, followed by irrigation and then hydropower. The public sector initiative is essential for coordinated efforts by related agencies and also for assuring public acceptance.

5.2.2 Water demand and supply

(1) Water potential

Surface water potential

1) Total run-offs

The Study Area has been divided into sub-basins, and the surface water run-off has been estimated by sub-basin based on the drainage area, average annual rainfall and run-off coefficient. The river basin division has been adapted to provincial administrative division, and estimates have been compiled by "adapted province" (Table 5.1).

Table 5.1 Estimated Surface Water Runoff by "Adapted Province"

Province	Estimated Drainage Area (km ²)	Annual Rainfall (mm)	Runoff Coefficient	Estimated Runoff (Unit: 10 ⁶ m ³)
Nakhon Nayok	448	1,677	0.424	347
Prachin Buri	11,108	1,626	0.225	4,064
N. Ratchasima	15,965	1,086	0.135	2,341
Buri Ram	9,835	1,165	0.270	3,094
Surin	10,739	1,224	0.186	2,445
Si Sa Ket	7,723	1,226	0.083	786
U. Ratchathani	19,309	1,520	0.126	3,698
Mukdahan	3,498	1,467	0.177	908
Yasothon	2,095	1,369	0.186	533
Total	80,760	-	-	18,216

2) Dependable run-offs

The total estimated run-off in the Study Area is 17.4 billion m³. This total can not be fully utilized effectively due to river flow variation. According to flow duration curves of some rivers in the Study Area, low stream flow constitutes about 25% of the total flow. Thus the total dependable run-off in the Study Area is estimated to be 4.6 billion m³.

The Study Area has another major problem: the presence of subsurface salt beds which tend to make water and soil salty. Surface run-offs on salty soil can not be easily used for irrigation nor drinking purpose, even if the run-off volume is regulated. Distribution of salty soil is found out from hydrological maps of the Department of Mineral Resources, Ministry of Industry (1977).

Based on these maps, the ratio of river basin area not affected by the salt problem has been determined by "adapted province". The amount of water that can be relied on for irrigation and drinking purpose has been estimated as shown in Table 5.2.

Table 5.2 Estimated Amount of Reliable Water by "Adapted Province"

Province	Estimated Dependable Runoff (10 ⁶ m ³)	Ratio of Land not Affected by Salt (%)	Estimated Amount of Reliable Water (10 ⁶ m ³)
Nakhon Nayok	87	50	44
Prachin Buri	1,016	25	254
N. Ratchasima	585	50	293
Buri Ram	773	80	618
Surin	612	50	306
Si Sa Ket	197	70	138
U. Ratchathani	924	80	739
Mukdahan	227	40	91
Yasothon	133	80	106
Total	4,554	-	2,589

The total amount of water that can be relied upon even in the driest year has been estimated at about 2.6 billion m³. This is only an indicative number, and the estimate is probably conservative.

Groundwater potential

1) Groundwater distribution

Distribution of groundwater in the Study Area has been examined based on the Hydrogeological Map of the Northeastern Thailand prepared by the Department of

Mineral Resources, Ministry of Industry. The groundwater potential is classified as follows.

<u>Class</u>	<u>Yield</u>	<u>Water quality</u>	<u>Characteristics</u>
I	Highest	Over 90% good quality	Gravelly and sandy deposit
II	High	Over 95% good quality	Medium high terraces; depth less than 60 m
II	Medium	Over 80% good quality	Mound and depression type topography
IV	Low	Over 90% good quality	Decomposed zone or fractures of intrusive rocks
V	-	50% good quality, 50% salty	Flat land
VI	-	Over 90% salty	
VII	unproductive sand		Yellow wish gray to grayish pink massive stone and conglomerate

Distribution of these classes of land in the Study Area is shown in Figure 5.1.

2) Groundwater potential

To estimate the groundwater potential in the Study Area, it is assumed that large artesian wells are located at nodes of 1.0 km grid to avoid excessive drawdowns due to interference by neighbouring wells. A pumping rate is assumed for each class of groundwater potential area. Based on 10-hour pumping per day for 300 days per year, number of wells that can be located in the groundwater potential area under classes I through IV, and ratios of successful wells, the groundwater potential is estimated by province as summarized below in Table 5.3.

Table 5.3 Groundwater Potential in the Study Area

Groundwater Province	Groundwater Potential Area by Class (km ²)Total				Potential (10 ⁶ m ³ /year)
	I	II	III	IV	
Nakhon Nayok	877	-	130	-	9.7
Prachin Buri	491	-	3,200	-	12.6
N. Ratchasima	591	-	3,167	3,392	18.0
Buri Ram	-	-	2,073	5,673	12.2
Surin	-	-	1,690	2,271	6.9
Si Sa Ket	-	202	5,056	617	13.6
U. Ratchathani	217	1,893	8,082	3,251	35.8
Mukdahan	-	-	449	1,246	2.7
Yasothon	-	147	2,460	-	6.5
Total	2,176	2,242	26,307	16,450	118.0

The total amount of groundwater that may be safely extracted has been estimated at 118 million m³ in the Study Area. The estimate is crude, but it is clear that the groundwater availability is much smaller than the surface water availability by an order of magnitude.

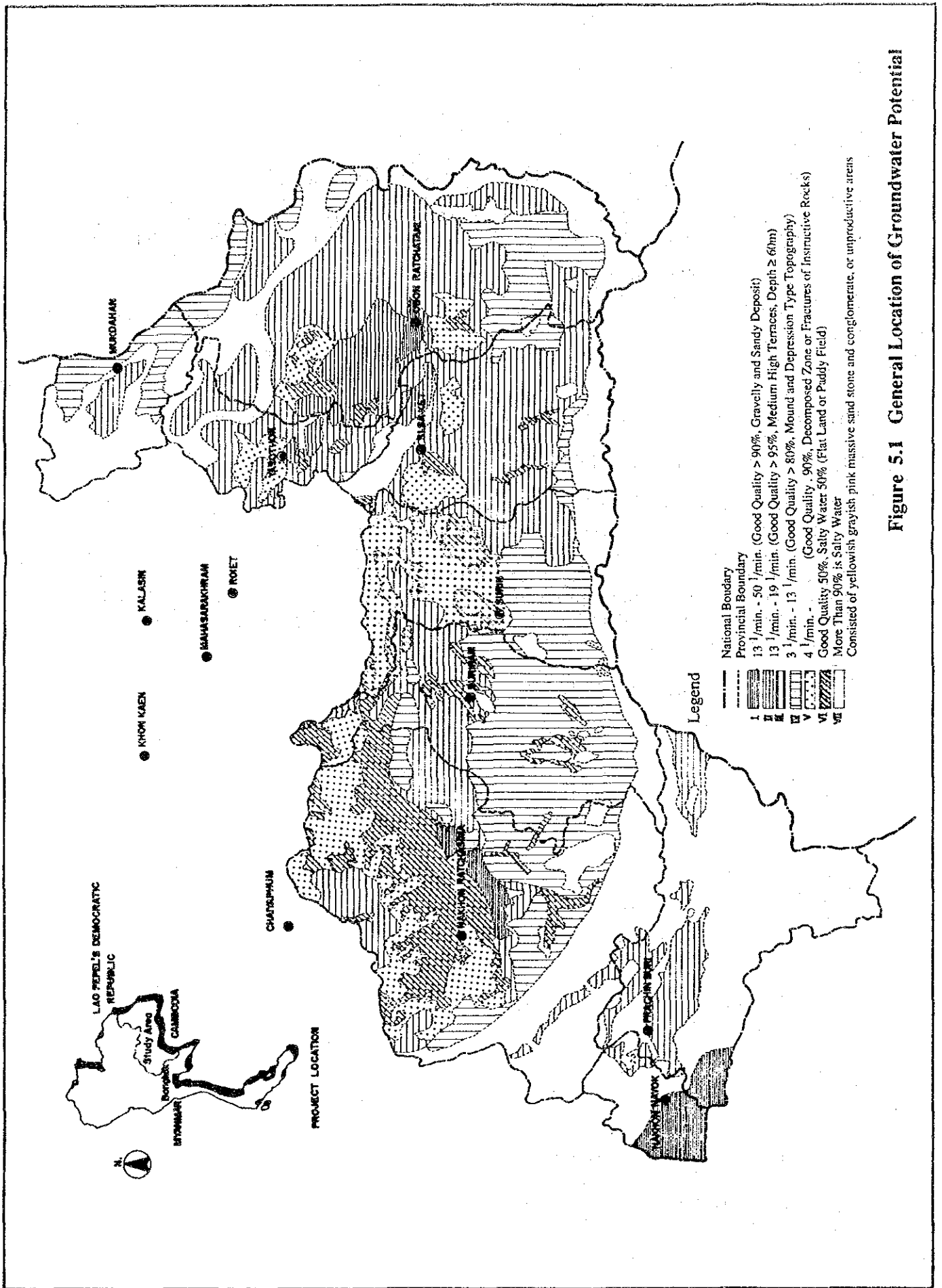


Figure 5.1 General Location of Groundwater Potential

(2) Water demand projection

Water demand for drinking and other domestic uses and also for domestic animals has been projected to the year 2000 and 2010. This projection follows the population growth and increase in domestic animals for the balanced development alternative.

Unit water use

Unit water use for various purposes in rural areas has been set as given in Table 5.4.

Table 5.4 Unit Water Use for Water Demand Projection in Rural Areas

Use	Unit Water Use (l/day/head)
Human use: Drinking	5
Domestic	45
Domestic animals: Buffalo/Cattle	50
Swine	20
Chicken/Duck	0.15

Source: Office of Accelerated Rural Development, Ministry of Interior

The unit water use in urban areas is set at 225 l/day/capita including both drinking and other domestic uses.

Projected water demand

Results of the water demand projection are summarized in Table 5.5 (details in Sector Report). As shown in the table, the total water demand for human and animal consumption is projected to reach 361 million m³ by 2000 and 494 million m³ by 2010.

Table 5.5 Projected Water Demand for Human and Animal Consumption

Province	2000			2010		
	Human Use	Domestic Animals	Total	Human Use	Domestic Animals	Total
Nakhon Nayok	5.7	0.5	6.2	6.5	0.7	7.2
Prachin Buri	20.7	5.0	25.7	27.2	6.9	34.1
N. Ratchasima	82.9	14.0	96.9	131.6	17.6	149.2
Buri Ram	35.2	10.0	45.2	44.5	12.5	57.0
Surin	29.9	11.2	41.1	36.5	14.6	51.1
Si Sa Ket	30.7	10.4	41.1	37.2	13.6	50.8
U. Ratchathani	56.2	16.0	72.2	77.4	23.5	100.9
Mukdahan	9.3	4.5	13.8	16.9	6.2	23.1
Yasothon	13.5	4.1	17.6	14.1	6.7	20.7
Study Area	285.4	75.7	361.1	391.9	102.3	494.1

(3) Future water balance

Future water balance is examined based the water potentials and the projected water demand presented above. The balance is checked for municipal and non-municipal water as well as the total demand for human and animal consumption, and prospects for irrigation water supply are also indicated.

Total water balance

The projected total water demand for human and animal consumption is compared with the estimated water potential by province (Table 5.6).

Table 5.6 Comparison between Water Demand and Potentials

(Unit: 10⁶ m³/year)

Province	Total Water Demand for Human and Animal Use		Water Potentials	
	2000	2010	Surface Water	Groundwater
Nakhon Nayok	6.2	7.2	44	9.7
Prachin Buri	25.7	34.1	254	12.6
N. Ratchasima	96.9	149.2	293	18.0
Buri Ram	45.2	57.0	618	12.2
Surin	41.1	51.1	306	6.9
Si Sa Ket	41.1	50.8	138	13.6
U. Ratchathani	72.2	100.9	739	35.8
Mukdahan	13.4	20.3	91	2.7
Yasothon	18.0	23.6	106	6.5
Total	361.1	494.1	2,589	118.0

For all the provinces in the Study Area, the estimated water potentials far exceed the water demand projected for the balanced development. Water potentials are particularly high in Ubon Ratchathani, Buri Ram and Surin.

Municipal and non-municipal water

The total water demand is broken down into municipal and non-municipal water. The municipal water is expected to be supplied by PWA. The current PWA supply is compared with the projected municipal water demand by province (Table 5.7).

Table 5.7 PWA Water Supply and Projected Municipal Water Demand(Unit: 10⁶ m³/year)

Province	Municipal Water Demand		PWA Water Supply in 1990
	2000	2010	
Nakhon Nayok	2.1	3.0	2.1
Prachin Buri	6.1	11.5	5.5
N. Ratchasima	47.4	98.7	4.6
Buri Ram	7.7	12.5	3.3
Surin	5.1	8.1	4.0
Si Sa Ket	4.5	7.1	2.3
U. Ratchathani	20.5	37.1	7.9
Mukdahan	4.0	7.5	1.2
Yasothon	2.9	4.8	1.6
Total	100.8	190.3	32.5

The supply capacity for municipal water will have to expand by 210% in the Study Area by the year 2000. In particular, Nakhon Ratchasima and Ubon Ratchathani would have to expand their supply capacity 10.3 times and 2.6 times, respectively by 2000, if the municipal water demand should be completely satisfied.

Irrigation water

The present water supply capacity for irrigation is compared with the non-municipal water demand and the water potentials (Table 5.8).

Table 5.8 Irrigation Water Supply, Non-Municipal Water Demand and Water Potentials(Unit: 10⁶ m³/year)

Province	Present Irrigation Water Supply *	Non-Municipal Water Demand		Water Potentials	
		2000	2010	Surface Water	Groundwater
		Nakhon Nayok	-		
Prachin Buri	-	146	15.7	268	14.3
N. Ratchasima	830.0	35.5	32.9	280	29.2
Buri Ram	305.4	27.5	32.0	534	32.3
Surin	141.2	24.8	28.4	285	16.2
Si Sa Ket	134.7	26.2	30.1	138	22.9
U. Ratchathani	145.6	35.7	40.3	662	54.3
Mukdahan	70.3	5.3	6.6	91	7.1
Yasothon	55.6	10.5	12.1	106	10.1
Total	1,682.8	184.6	201.6	2,408	190.7

* total water storage volume

The non-municipal water demand by 2000 in most provinces can be mostly satisfied by the groundwater alone distributed extensively in rural areas. Exceptions are Prachin Buri, Nakhon Ratchasima, Surin and Si Sa Ket. Substantial expansion of irrigation water supply is difficult for most provinces, even if the surface water potential is fully devoted to irrigation. The provinces of Ubon Ratchathani, Buri Ram, Prachin Buri and Surin are relatively better off with this respect. Future irrigation development should be directed to (1) effective utilization of existing irrigation facilities with consolidation/integration, (2) efficient development of surface water, (3) small scale development by groundwater, and (4) establishment of less water intensive crops and use of water saving irrigation technology (e.g. drip irrigation).

5.2.3 Development projects and support measures

(1) Small pumping reservoirs development

The Korat plateau is generally flat, and storage of water in large scale is difficult. Especially in Nakhon Ratchasima, potential sites for dams in significant scale have been practically all developed. Water storage in small scale is possible by utilizing natural depressions and excavating suitable sites. Several such sites have been identified (Figure 5.2). Important characteristics of the small pumping reservoirs are the following. First, they are linked with the nearby river systems so that more water can be stored extracted from the rivers during the rainy season and excess water can be discharged for use further downstream. Second, they are developed for multiple objectives, including water supply for domestic, industrial and agricultural uses, aquaculture and local recreation. Typical dimensions of an impoundment are surface area of 10-20 ha and depth of 6 m with the effective storage of some 0.5-1.0 million m³. A preliminary feasibility analysis is found in a separate volume.

(2) Lam Nam Chi/Lam Plai Mat multipurpose water resources development

The project will develop the Lam Nam Chi and the Lam Plai Mat river basins, main tributary basins of the Mun river, for multiple purposes. A comprehensive development and management plan needs to be prepared first. The plan should include a comprehensive water supply scheme for this dry area, irrigation development with groundwater and small pumping reservoirs, and a plan for better watershed management through afforestation and improved land use. This project is essential for the development of the central part of the Lower Northeast around Surin and Buri Ram.

(3) Nakhon Nayok/Prachin Buri river basins multi-purpose water resources development

The project will develop the two tributaries of the Bang Pakong river for multiple purposes aiming at the urban areas of Prachin Buri and Nakhon Nayok as well as upper watershed areas.

Components include dams on the upper catchment areas, and related works for flood control of the Nakhon Nayok and Prachin Buri cities, low flow augmentation to reduce salt water intrusion, and improvement of irrigated agriculture. A feasibility study should cover crop diversification under irrigation, tourism, and urban development, and reflect existing programs for the Bang Pakong river.

LEGEND

- Major City
- Major Roads
- ⋯ Railroads
- ⋯ Major River
- - - Provincial Boundaries
- ⋯ International Boundaries

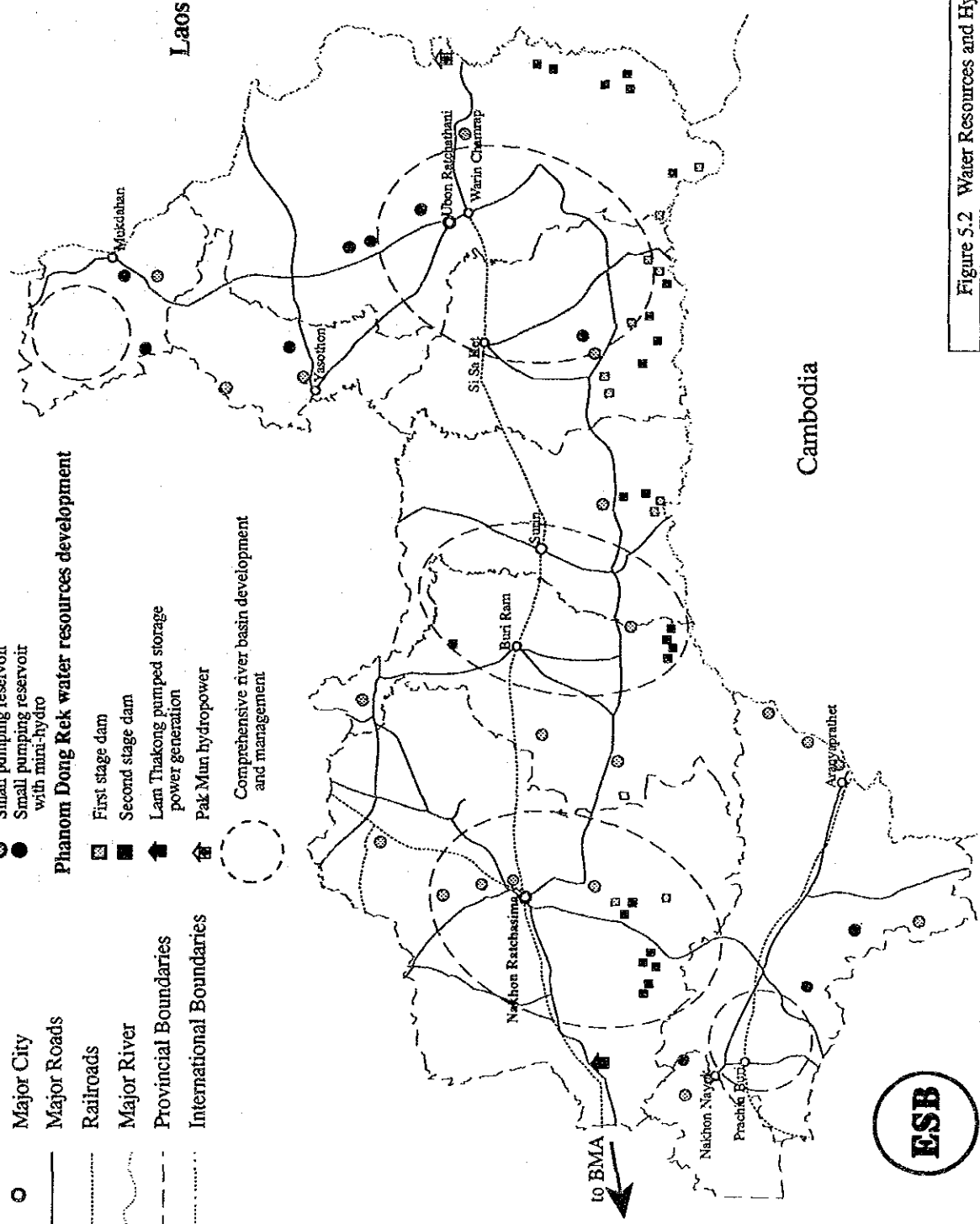
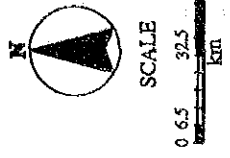
Small pumping reservoir development

- ⊗ Small pumping reservoir
- Small pumping reservoir with mini-hydro

Phanom Dong Rek water resources development

- ▣ First stage dam
- ▣ Second stage dam
- ⬆ Lam Thakong pumped storage power generation
- ⬆ Pak Mun hydropower

- Comprehensive river basin development and management



Note: Basic elements of this map composition were derived from the Geographic Information System (GIS) Database developed in the study.

Figure 5.2 Water Resources and Hydro-power Development Projects
The Study on the Regional Development Plan for the Lower Northeast
and the Upper East Regions in the Kingdom of Thailand

(4) Yasothon water network development

The Chi river will be effectively connected with either the Se Bai river or the Mun river by a network of canals to improve water use efficiency for irrigation and other purposes and to control floods better. The first step is to study water demand for various purposes and potentials of these three rivers.

(5) Revised water jar program

As a result of extensive efforts under the original "water jar" program, collection of rain water in large ceramic containers is now an important mode of water supply mainly in rural areas of the Study Area. There are on an average 1.8 jars in the seven provinces in the Lower Northeast. A few more jars per household would help to bridge the water availability gap due to extended droughts. Thus this program should be revised focusing on the most critical areas where no realistic alternative water supply is considered.

(6) Huai Bang Sai multipurpose water resources development

The project consists of three storage dams, two diversion dams, a hydroelectric power plant, and irrigation facilities in the Huai Bang Sai river basin occupying the northern part of Mukdahan. The project will be reformulated in the light of the Master Plan and cost-effectiveness of storage dams reviewed as well as environmental effects.

(7) Lam Dom Yai/Huai Tha multipurpose water resources development

The project will develop the Lam Dom Yai and the Huai Tha river basins in the Ubon Ratchathani and the Si Sa Ket provinces. Additional sites for small pumping reservoirs will be identified through further studies. The existing plan for the Lam Don Yai dam will be reviewed. Multipurpose projects would be formulated for domestic water supply, irrigation and hydropower generation. Recreation and environmental management may also be incorporated for some projects. These projects will also support the conversion of agricultural land use, typically from paddy fields to managed pastures or field crops for lands of sandy or skeletal soil.

(8) Groundwater exploration

This is to expand the use of groundwater, an important source of water supply in rural areas in the Study Area. Existing data kept by the Department of Mineral Resources will be thoroughly reviewed to identify more promising areas particularly in the provinces of Nakhon Ratchasima, Buri Ram, Surin, Si Sa Ket and Yasothon. Boring and pumping test will be conducted before the development of production wells.

5.3 Power and Energy

5.3.1 Objectives and strategy

(1) Characteristics of LNE-UE energy situations

Energy consumption

The less developed status of the Study Area (LNE-UE) is reflected in its energy use. The electricity consumption in the Study Area constitutes only less than 5% of the total consumption in Thailand. Per capita electricity consumption in the Study Area is only one-fifth of the national average (681 kWh in 1990), and the electrification ratio with respect to population served is much lower than the national average (64.4% in the Lower Northeast compared with 73.6% in the kingdom).

Increase in the consumption of petroleum products in the Northeast is much slower (9.8% per annum in 1980-90) than the increase in the whole kingdom (15.9% p.a. during the same period). However, the electricity consumption in the Study Area has been growing at high rates in recent years (12.9% per annum in 1987-91).

Energy supply and resources

The Study Area has very limited energy resources. No fossil fuel resources endowment has been reported and hydropower potential is also small within the Study Area. There exist only a small hydropower plant (40 MW at Sirindhorn) and a small gas turbine unit (14 MW at Nakhon Ratchasima).

However, there are some bright prospects as well. The Study Area is expected to benefit from increasing electricity import from Laos and the extension of natural gas pipeline from Bang Pakong to Nakhon Ratchasima.

Prospects for rural energy seem reasonable. In addition to common agricultural wastes such as rice husk and straw, the Study Area has large amount of bagasse and cassava waste as well as animal wastes. Some other energy crops may also be promising. Another rural energy potentially important in the Study Area is solar energy.

(2) Objectives

Objectives for energy development in the Study Area support the LNE-UE regional development as follows.

- 1) To increase total energy supply to support higher industrialization and to diversify sources of rural energy to support income generating activities in rural areas;
- 2) To make maximum use of locally available energy sources including plant and animal wastes to minimize negative environmental effects of energy development; and
- 3) To support self-help efforts by rural populace to increase energy supply and to minimize social problems associated with large scale energy development for sustainable and socially acceptable development.

(3) Strategy

Rural energy

Use of abundant agricultural and animal wastes should be much expanded. Technology for biogas digester using animal wastes is readily adoptable and used primarily for cooking to reduce the use of fuel wood. Of various agricultural wastes, rice husk alone can generate some 700 GWh, sufficient to meet all the present residential demand for electricity, if half of the paddy husk generated is collected and used.

Use of biomass should be extended to other energy crops in the future. They may include cassava, sugarcane (by product) and leucaena.

Solar energy has potential for wide application. Use of solar water heaters can be expanded immediately not only for hot water supply to hotels, hospitals and other public facilities, but also for cleaning slaughter-houses, industrial process heat and other uses. Photovoltaic technology can be applied to rural electrification in general, and for pumping irrigation water and telecommunication purposes among others in particular.

Industrial energy

Probably the only major prospect for power generation within the Study Area is for co-generation. Extension of the natural gas pipeline to Nakhon Ratchasima will enhance this prospect. Otherwise, extension of power transmission and distribution system would be the prime option. A joint effort with the neighboring countries such as Laos in the development of power transmission and distribution facilities as well as power generation facilities would be a possibility to be looked into further. Improvement of supply stability and reliability by replacement of equipment as well as further network interconnection is as important as the expansion of service areas.

5.3.2 Development targets

According to the socio-economic framework for balanced development of the LNE-UE master plan, the per capita GRDP in the Study Area is expected to increase from about US\$500 at present to over US\$2,000 by 2010. This growth would be supported by high industrialization, modernization of agriculture and other associated activities. Economic structure will change in a fundamental way. This will change energy use structure. More commercial energy will be used and per capita energy consumption will increase by several times.

While every effort should be made to increase the use of local energy including non-conventional forms of energy, increasing demand will have to be met largely by import from other regions. They are mainly in the forms of import of petroleum products and extension of power transmission lines. Supply of other sources of energy will also depend much on external supports in the form of provision of technology and use facilities/device (e.g. solar device).

Levels of energy supply expansion are indicated below for commercial energy as a whole and electricity in particular.

Commercial energy

According to the Seventh Five Year Plan, primary energy production is expected to grow at 8% per annum throughout the kingdom. The Plan states also that the growth of commercial energy consumption should be suppressed to less than 10% per annum.

Consumption of petroleum products, constituting some 60% of the total energy consumption, grew at 15.9% per annum in the kingdom during 1987-90, while this rate was lower at 11.3% in the Northeast. The growth of petroleum products consumption in the Study Area will be necessarily at over 10% per annum during the master plan period. Including other forms of energy, the commercial energy consumption in the Study Area will grow at 10% per annum at least. This exceeds the expected growth of primary energy production. Thus increasingly large portion of commercial energy consumption in the Study Area will have to be supplied by other regions and import, including increasing electricity import from Laos.

Electricity

The per capita GRDP in the Study Area in 2010 is comparable with that in some of newly industrialized countries (NIC's) such as Malaysia (\$2,213 in 1989), South Africa (\$2,446) and Brazil (\$2,280). The per capita electricity consumption will also increase accordingly. Assuming per capita consumption of 1,000 kWh in 2010, the total electricity consumption will reach 13,360 GWh, representing eight times increase from 1991.

Electrification ratio in the Study Area is already high on the tambon basis. However, electrification ratio on population basis will have to be increased further to catch up with the national average. The government aims at increasing electrification ratio on population basis by using a solar PV system throughout the kingdom during the Seventh Five Year Plan period. Extending this effort throughout the master plan period, the electrification ratio in the Study Area would increase to over 70%, still slightly lower than the present national average. Therefore, other efforts need to be initiated in the Study Area.

5.3.3 Development projects and support measures

(1) Lam Takhong pumped storage power generation

This is an on-going project for which a feasibility study has been completed and detailed design will start soon. A reservoir will be created on the upstreams of Lam Takhong river, a tributary the Mun river, and pumped storage hydropower generation will be conducted with 1,000 MW generating capacity by using the existing Lam Takhong reservoir as a lower reservoir for flow regulation. Implementation of the power plant will be in stages.

(2) Natural gas pipeline extension

PTT once planned to construct a natural gas pipeline between the Bang Pakong power plant and the Nam Phong combined cycle plant in Khon Kaen via Nakhon Ratchasima (Figure 5.3). As the Nam Phong plant can be operated with the natural gas from a nearby field, it is necessary to extend a pipeline from the Bang Pakong power plant only to Nakhon Ratchasima.

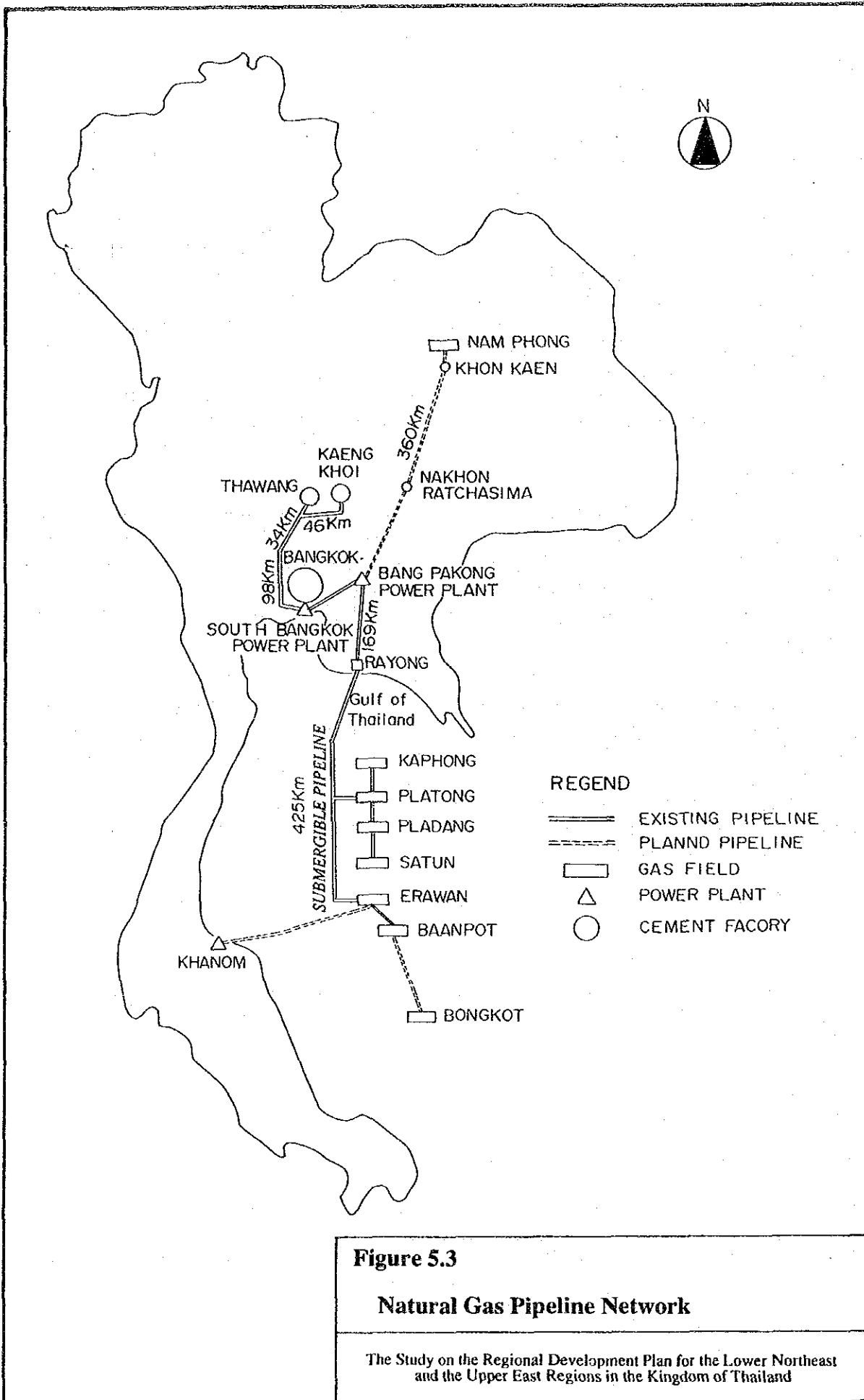


Figure 5.3

Natural Gas Pipeline Network

The Study on the Regional Development Plan for the Lower Northeast and the Upper East Regions in the Kingdom of Thailand

(3) Rural energy program

This program represents renewed efforts to increase and diversify rural energy supply to prevent deforestation by reducing the use of fuelwood as well as to support various rural activities. Promising energy sources include biogas using animal wastes, biomass including plant and animal wastes, solar and mini-hydro as well as extension of electricity distribution. Support measures include subsidies for installation of energy facilities, provision of seedlings/saplings for energy plants and demonstration of solar device as well as technical extension.

(4) Solar PV application

Solar PV application will be expanded not only for rural electrification but also for pumped irrigation and drainage, telecommunications, fencing for livestock, and other uses.

(5) Rice husk power generation

Rice husk will be used to generate electricity for rural industries and other uses. Steam and hot water supply is also expected for rural industries and public sanitary uses. Pilot plants should be established in major paddy producing areas in Surin, Buri Ram, Si Sa Ket and Ubon Ratchathani.

(6) Co-generation system

A high efficiency system for electricity generation and hot water supply will be established. Hot water can be supplied to hospitals, hotels and food processing industries. The natural gas pipeline extension described above will provide the fuel for the system.

(7) Solar water heater application program

Use of solar water heater will be expanded for public facilities and service industries. Government agencies should be encouraged to take the initiative for installation in their offices. Incentive measures should be provided to the private sector for local manufacturing as well as installation of solar water heaters.

(8) Multi-purpose water resources development

Water resources development in the Study Area should be formulated as much as possible for multi-purposes to enhance the project viability through effective use of the limited resources. The following projects have the hydropower development component (Section 5.2).

- Lam Dom Yai/Huai Tha multi-purpose water resources development
- Huai Bang Sai multi-purpose water resources development

5.4 Telecommunications

5.4.1 Objectives and strategy

(1) Constraints and priority

Constraints

Telecommunications in the Study Area are constrained by biased investments in the past, existing institutions and limited human resources and construction capacity. The latter may be summarized as follows (Sector Report):

- 1) Outdated rules and regulations limiting the private sector to join the public sector for a wider and more flexible telecommunication service,
- 2) Operational inefficiency represented by duplicated investments by public agencies, lack of coherent policies covering various aspects of communications, and inadequate coordination of work programs and control of service fees,
- 3) Lack of flexibility in radio frequency management that would allow most efficient use of valuable resources of frequencies,
- 4) Shortage of engineers and technicians in general that has been furthered by flowing out of educated people from provinces, and
- 5) Limited construction capacity, far short of requirements to meet the NESDB target of 10 telephone lines per 100 population by the end of Seventh Five Year Plan.

Priority

Two factors point to the rectification of the biased investments in the past. First, a government policy is to vitalize rural areas by encouraging investments by the private sector. Telephone links to the farthest peripheries would be effective to encourage various private sector activities.

Second, the development status of Thai economy itself calls for increasing attention to rural areas in telecommunication development. For example, as many people are out migrating from rural areas into Bangkok and other major cities, calls to/from other family members would become essential not only for family ties but also for social stability. Also for further socio-economic development of the kingdom as a whole, the provision of various information related to markets, business opportunities and social services through both institutional and private channels would be a prerequisite.

These two factors have direct relevance to the Study Area, which are predominantly rural. Thus the priority of planning telecommunications for regional development in the Study Area would be accorded to the expansion of telephone networks to every tambon.

Another important aspect for telecommunications in the Study Area is to establish international telecommunication links between major cities in the regions and

Indochina for further promotion of border trade and distribution. It would allow domestic business users to communicate effectively with their foreign partners/clients without having to be connected through the long distance telephone exchange in Bangkok. Plans need to be drawn up to build an international transit switching center complete with a linking network so as to satisfy the demand of local business and industries by providing efficient international telephone, data communications and other supplementary up-to-date services in the integrated services digital network (ISDN).

(2) Objectives

Objectives of LNE-UE telecommunications development support the regional development objectives by placing emphasis on the two priority areas described above.

- 1) To support international trade, industrial and other business activities by offering high quality services linking major cities in the Study Area to one another and to neighboring countries; and
- 2) To improve the provision of telecommunication services in rural areas to maintain/strengthen social ties and to improve access by rural people to business opportunities and social services.

(3) Strategy

Rural telecommunication

There exist digital radio concentrator systems (DRCS) in the Study Area installed during 1986-1991. These systems cover less than 30% of tambons with only three telephone lines on an average. The number of subscriber lines per system should be increased.

Two systems are considered for this purpose : DRCS and multiple access subscriber system (MASS). Both systems use time division multiplex. A radio concentrator system will be of lower priority from the point of the available maximum number of subscribers per system. A radio multiple access system would be recommended for the installation for remote dispersed subscribers in the Study Area.

Equipment costs for MASS on base stations and terminal stations are slightly higher than those for DRCS. However, the cost per subscriber is lower for MASS than for DRCS.

TOT has just launched the rural public long distance telephone project for completion in 1996. Although it is not clear yet which system will be adopted for the projects, MASS may be more suitable.

Teleport

To support high levels of economic activities within the Study Area linked with Indochina, a "teleport" should be established as a base for comprehensive telecommunication services and information exchanges. To realize this concept, the introduction of the ISDN is essential.

This network would make it possible to provide all the advanced telecommunication services by using present satellite systems such as teleconference, high speed digital transmission, packet exchange, image communication and high reliability communications.

The network will support a wide range of activities such as agricultural marketing, international tourism, financial services, medical care and resource management. Examples of information systems for those activities include agricultural information system, rainfall and water level telemetering system, medical treatment information system, and tourism information system.

5.4.2 Development targets

Development targets for telecommunications are set by phase for both rural telecommunications and teleport related services.

Phase I (upto 1996)

- 1) To install telephone lines in every tambon
This target will be achieved through the on-going TOT rural public long distance telephone project.
- 2) To establish mobile telephone systems in all the nine provinces
To attain this target, a cellular mobile radio system will be expanded by the private sector under the authority of both TOT and CAT.
- 3) To upgrade quality of telephone services
In 1990, one out of two calls did not get through due to congestion, technical faults and other reasons. This will be improved.

Phase II (1997-2001)

- 1) To install telephone lines in every village
- 2) To establish an information gateway
A satellite earth station will be established in Ubon Ratchathani as a gateway for in-coming and out-going information.

Phase III (2002-2010)

- 1) To establish a teleport
A teleport will be established in Ubon Ratchathani.
- 2) To build telecommunication links along the borders
The following links will be established to facilitate border trade:
 - Mukdahan - Savannakhet (Laos)
 - Chong Cham (Surin) - Northern Cambodia
 - Phibun Mangsahan/Chong Mek (Ubon Ratchathani) - Pakse (Laos)
 - Aranyaprathet (Prachin Buri) - Phnom Pehn (Cambodia)
- 3) To expand various telecommunication services

5.4.3 Development projects and support measures

(1) Rural telecommunications

The multiple access subscriber system will be established from local exchange stations of TOT located in major provinces (Figure 5.4). A base station will be installed within 40 km from the local exchange. A visual display unit will be provided for centralized operation and maintenance. The base station will be linked to terminals either directly or through repeater stations. Some repeater stations may use solar power. Access to foreign loans/grants under official development assistance should be improved to promote the project.

(2) Mobile telephone system

Three types of mobile telephone "cellular" have been opened for different frequencies. Cellular 470 MHz and 900 MHz were opened by TOT, and cellular 800 MHz operated by CAT. All the nine provinces in the Study Area should be covered by the cellular network under these systems. Provinces of Nakhon Nayok, Nakhon Ratchasima, Buri Ram, Si Sa Ket and Mukdahan are already included in the second stage of the TOT cellular 470 system. The outdated telecommunication act must be modified in accordance with the new technology.

(3) Telephone services upgrading

Telephone services will be upgraded for systematic preventive maintenance, monitoring and quick corrective maintenance. Telecommunication centers with telephone exchangers should have back-up functions, and main transmission routes should be doubled. A back-up system should have stand-by units for quick replacement, and repair shops should be well maintained with all the spare parts. Training for maintenance staff is another component of this program.

(4) Satellite gateway

CAT has a plan to establish a satellite gateway in the Study Area in 1998, which will be the third gateway following the existing Sri Racha gateway and the planned Nonthaburi gateway. The planned CAT gateway will be equipped with three parabolic antennas. The main function is for TV broadcasting. This gateway constitutes the first step of establishing a teleport.

(5) Teleport

A teleport will allow users to communicate effectively with foreign countries without having to be connected through the long-distance telephone exchange in Bangkok (Figure 5.5). An international transit switching center is planned with an initial capacity of 3,000 international circuits, complete with a linking network. This will satisfy demand of business and industry by providing efficient international telephone, data communications and other supplementary up-to-date services in the ISDN system.

Subscribers distributed in various patterns can be covered by locating terminals and repeaters in a cellular type configuration.

- B** : Base Station
- R** : Repeater
- T** : Terminal
- ⊙ : Omnidirectional Antenna
- ∪ : Parabolic Antenna
- △ : Horn Antenna

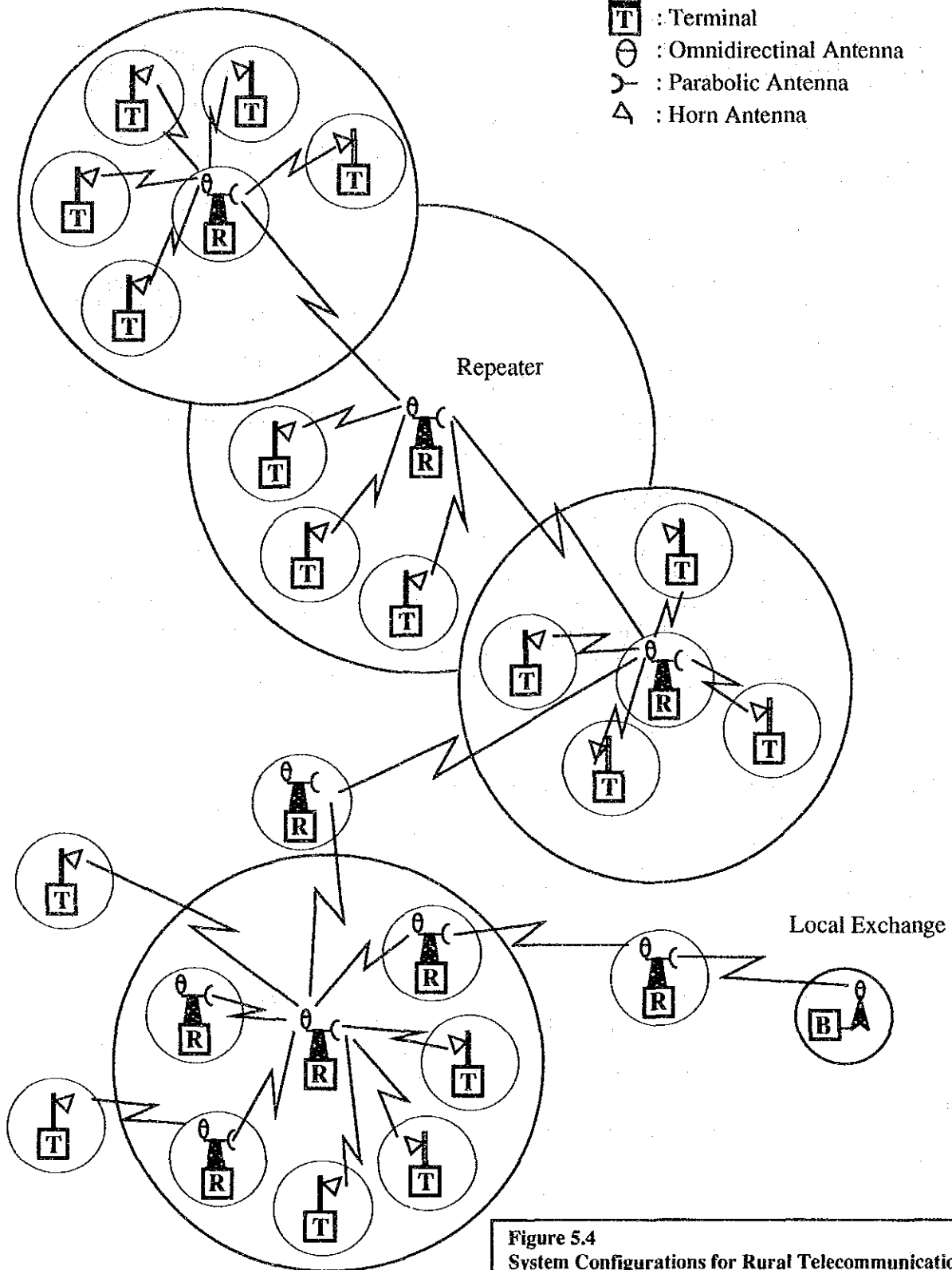


Figure 5.4
System Configurations for Rural Telecommunications

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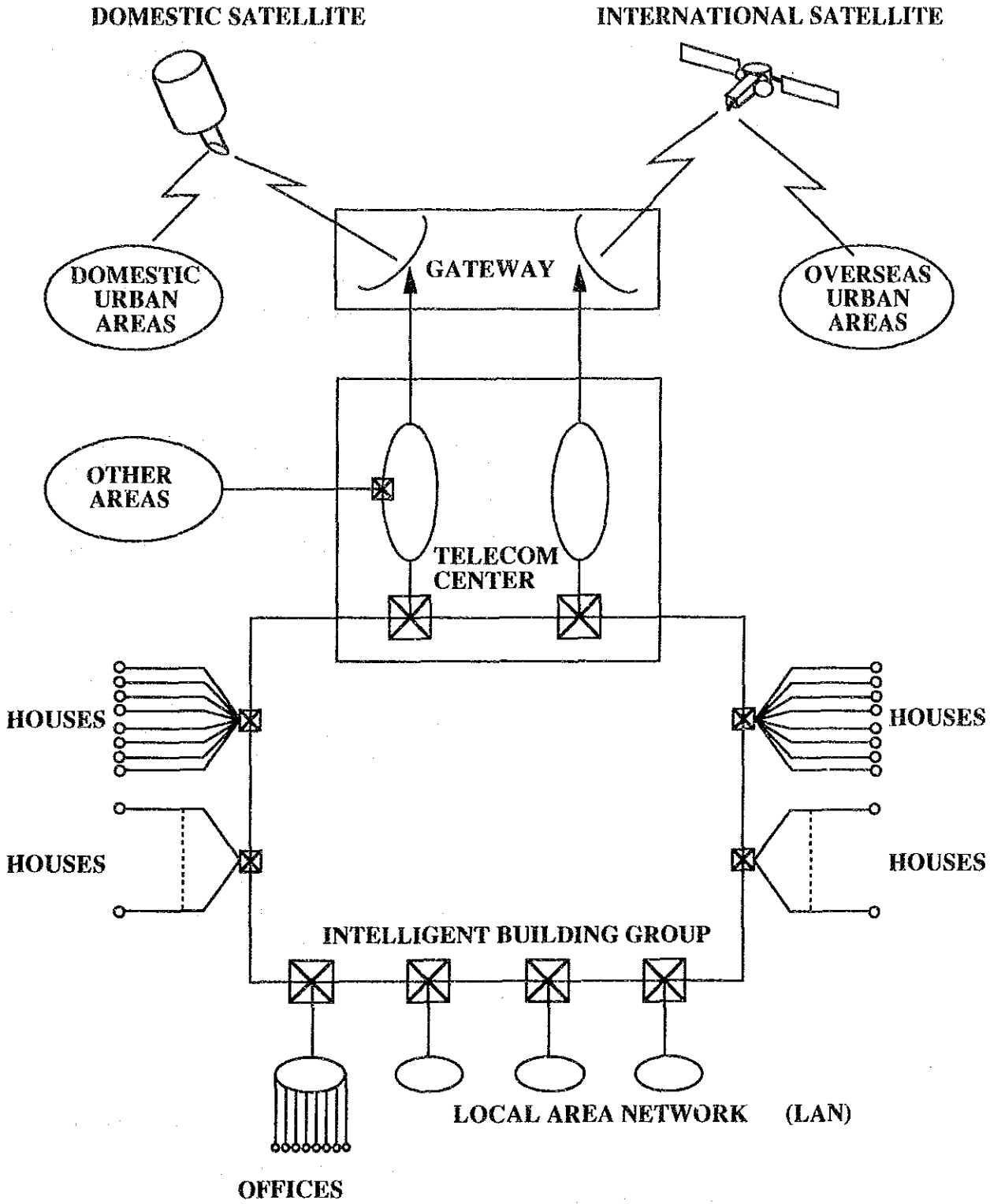


Figure 5.5
System Image for Teleport

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(6) Border links establishment

Main border trade centers in the Study Area will be linked with respective centers on the other side of borders. Efforts by telephone and telecommunication authorities of Thailand should be supported for negotiations with the neighboring countries.

5.5 Transportation

5.5.1 Objectives and strategy

(1) Constraints

Constraints to development related to the transportation system in the Study Area has been identified through the analysis on existing conditions (Sector Report). They are summarized by mode.

Artery roads

Connections between provincial capitals and between these and the BMA or the ESB have been analyzed by "circuitry factor". Dividing the actual shortest travel time by the minimum theoretical travel time between any pair of cities gives a number greater than 1.0 as the circuitry factor for this pair. Results have revealed that the most significant problems exist in connections between the ESB and the central and northeastern part of the Lower Northeast (Figure 5.6).

Rural roads

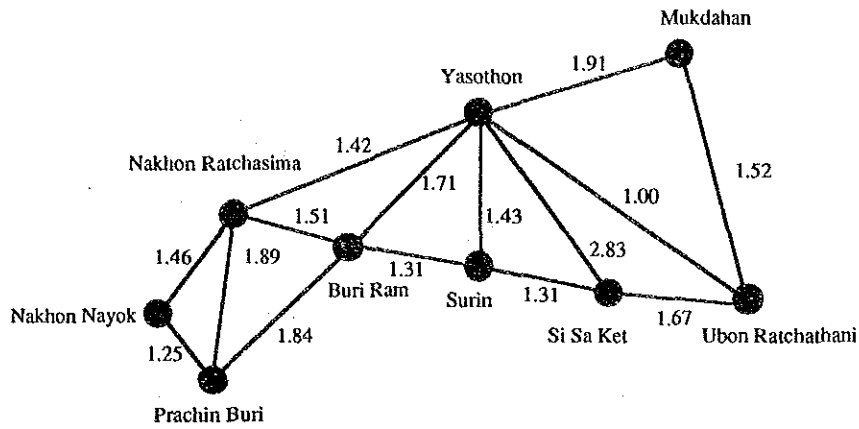
Over 10% of districts (ampoe) in the Study Area are not provided with bus services. The percentage becomes larger during the rainy season. Out of 11,855 villages (muban) in the Study Area, 449 are deprived of light bus services and the number increases to 1,639 during the rainy season. Light bus services are not frequent in 5,052 villages.

Railways

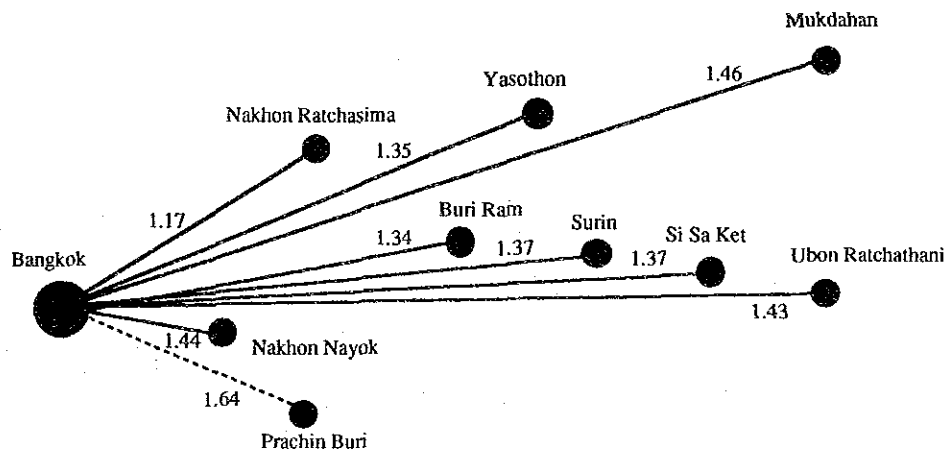
Both the northeastern and the eastern lines of SRT in the Study Area show significant train delays in some portions of the respective lines. The northeastern line suffers from gradient and curvature problems between Kaeng Khoi and Pak Chong, resulting in low hauling capacity and line capacity. Between Ban Prachi and Kaeng Khoi are additional line capacity problems for long distance passenger trains and freight trains.

Air transport

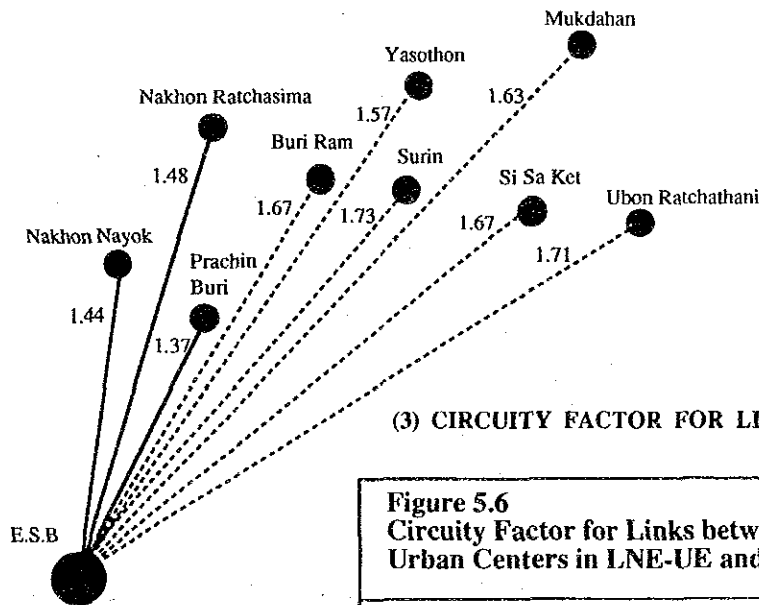
Effective service areas of major airports in the Northeast have been mapped as areas accessible to respective airports within an hour on existing roads (Figure 5.7). The lack of services is evident in the central part of the Lower Northeast, where the Buri Ram airport is now under construction.



(1) CIRCUITY FACTOR BETWEEN MAJOR URBAN CENTERS



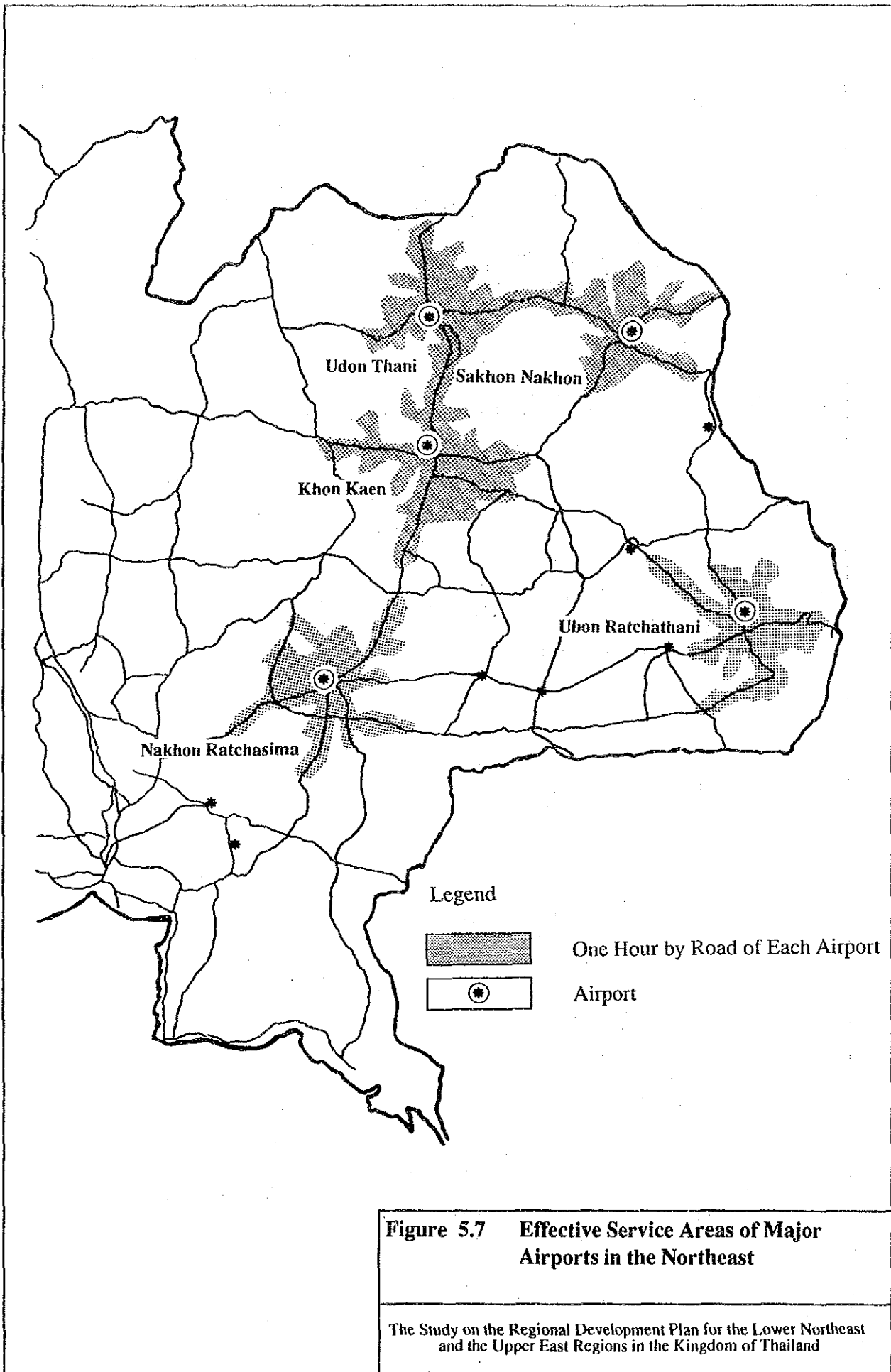
(2) CIRCUITY FACTOR FOR LINKS FROM BMA



(3) CIRCUITY FACTOR FOR LINKS FROM ESB

Figure 5.6
Circuitry Factor for Links between Major Urban Centers in LNE-UE and BMA/ESB

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Inland water transport

Port facilities and access roads to river ports on the Mekong river are generally poor. Problems in river transport on the Mekong, however, have not apparently emerged as the present transport demand is small.

(2) Objectives

The transportation network in any region dictates substantially spatial development of the region by affecting location of economic activities and associated distribution of settlements. Objectives of transport development in the Study Area naturally support the LNE-UE regional development objectives as follows.

- 1) To support industry and related activities in urban areas by enhancing comparative advantages for industrial location, and also crop diversification and rural industries in rural areas by improving rural access for input procurement and marketing;
- 2) To contribute to reducing vehicle damages, soil erosion, water pollution and air pollution as well as negative psychological effects on local people due to poor road conditions; and
- 3) To promote people's participation in planning and implementing transportation projects, particularly self-help efforts to manage and maintain rural roads.

(3) Prospects and strategy

Prospects

Planning for the development of transportation system in the Study Area should take account of the following prospects as well as the constraints described above.

i) Development of high-mobility society

Activity spheres tend to expand as income levels increase and information density becomes higher. Also time costs become higher as the income levels increase. These trends call for speeding up of people's movement.

ii) Internationalization of traffic

Border trade is expected to expand and international tourism is becoming more popular in Thailand as a whole and particularly in the Study Area. As a result, international traffic through the Study Area will become more important.

iii) Change in modal split

Importance of road transport will increase as income rises particularly in the Study Area where settlements are more dispersed. For passenger traffics, specialization by mode will become more pronounced. Air transport will certainly become more important for tourism and business travel purposes. The railway system will continue to be an important part of the transport

system in the Study Area, but its relative position in transporting passengers and bulk commodities will depend on further improvements of the system.

Strategy

Given the prospects and the constraints described above, the transport strategy for the Study Area is established as follows.

1) Regional artery

A strong regional artery should be newly established as the existing arteries do not serve the Study Area adequately. The new artery should serve particularly the central and northeastern part of the Study Area. This artery will link not only between the Lower Northeast and the Upper East in the Study Area but also between the ESB, the Study Area and the Indochina countries.

2) Gateways

Gateways to the Study Area should be improved. Nakhon Ratchasima, the main gateway, should strengthen its link with the BMA by the on-going expansion of route no.2 and the railway improvement. Buri Ram should become a tourism gateway with the completion of the new international airport. Gateways for border trade with the Indochina countries should be improved for access from these countries and other parts of the Study Area as well as for their urban functions.

3) Rural access

Improvement and good maintenance of rural roads would expand the market for agricultural produce from villagers' point of view, and expand the raw material base from processors' point of view. Considering the erodible characteristics of soil and intensive rainfall pattern often after extended drought, repair and maintenance would be as important as construction of new rural roads. Self-help efforts of villagers should be utilized for repair and maintenance of rural roads.

4) Development axes

Considering the limited industrial activities and the small size of most urban centers, existing development axes should be utilized effectively to develop urban centers along the axes for designated functions. In particular, the east-west axis connecting Nakhon Ratchasima and Ubon Ratchathani should be strengthened to develop urban centers in the central part of the Study Area for various functions. The north-south axis should also be strengthened to improve locational advantages of urban centers along the axis mainly for footloose industries.

5.5.2 Future transport system with modal split

Roads will continue to be the primary mode of transport for both inter- and intra-regional transportation in the Study Area. For commodities, transport by trucks on main arteries will become more common as the new regional artery is established and the main development axes strengthened. Passenger traffic will shift steadily from buses to private vehicles as income levels increase.

Along the east-west axis, the route no.24 will function as the main route for freight traffic because of relatively low utilization at present and high design standard. The routes no.226 and no.222 connecting provincial capitals will be mainly for local traffic in the near future. In the long term future, however, a high speed inter-city motorway may be introduced along these routes.

If the present quality of rail track is maintained and the existing bottlenecks resolved, roles of railway transport will increase in the future. Travel time can be much reduced with double-tracking, electrification and improved telecommunication system. This would make the rail transport more competitive than road transport for long distance passenger trips and bulk commodity transport.

Air transport would certainly become more important for tourism and business passenger travel purposes. Coordination of air transport with highways is important for intermodal transport network formation.

5.5.3 Development projects and support measures

(1) Regional artery establishment (New Indochina gateway road)

The project is to establish the main artery serving the Study Area. This artery is in fact an inter-regional artery linking the ESB and the Study Area as well as different parts in the Study Area. It would become an international artery, as it is extended further beyond the Mekong river to Laos and Vietnam. A branch artery may extend from Aranyprathet into Cambodia (Figure 5.8).

Initially existing roads should be utilized as much as possible. The first stage may be a link between the route no.33 in Prachin Buri and the route no.24 near the Buri Ram - Surin border. The route no.2169 from Yasothon will also be improved initially.

(2) Route no.24 improvement

The route no.24 is expected to function as the artery for freight transport. The project will improve this dual carriage way in view of deterioration since its construction and heavy usage expected in connection with future industrialization in the Study Area. The section between Nakhon Ratchasima and Nong Ki will be implemented by 1996 as planned by DOH.

(3) Rural road maintenance system

For regular maintenance and repair as well as management of rural roads, villagers will be organized and supported by the provision of basic skills and tools, under the supervision of local administrations. Such self-help efforts will reduce the costs of road maintenance, and provide more effective and timely services. Road maintenance funds that could be more directly used by local governments should be expanded.

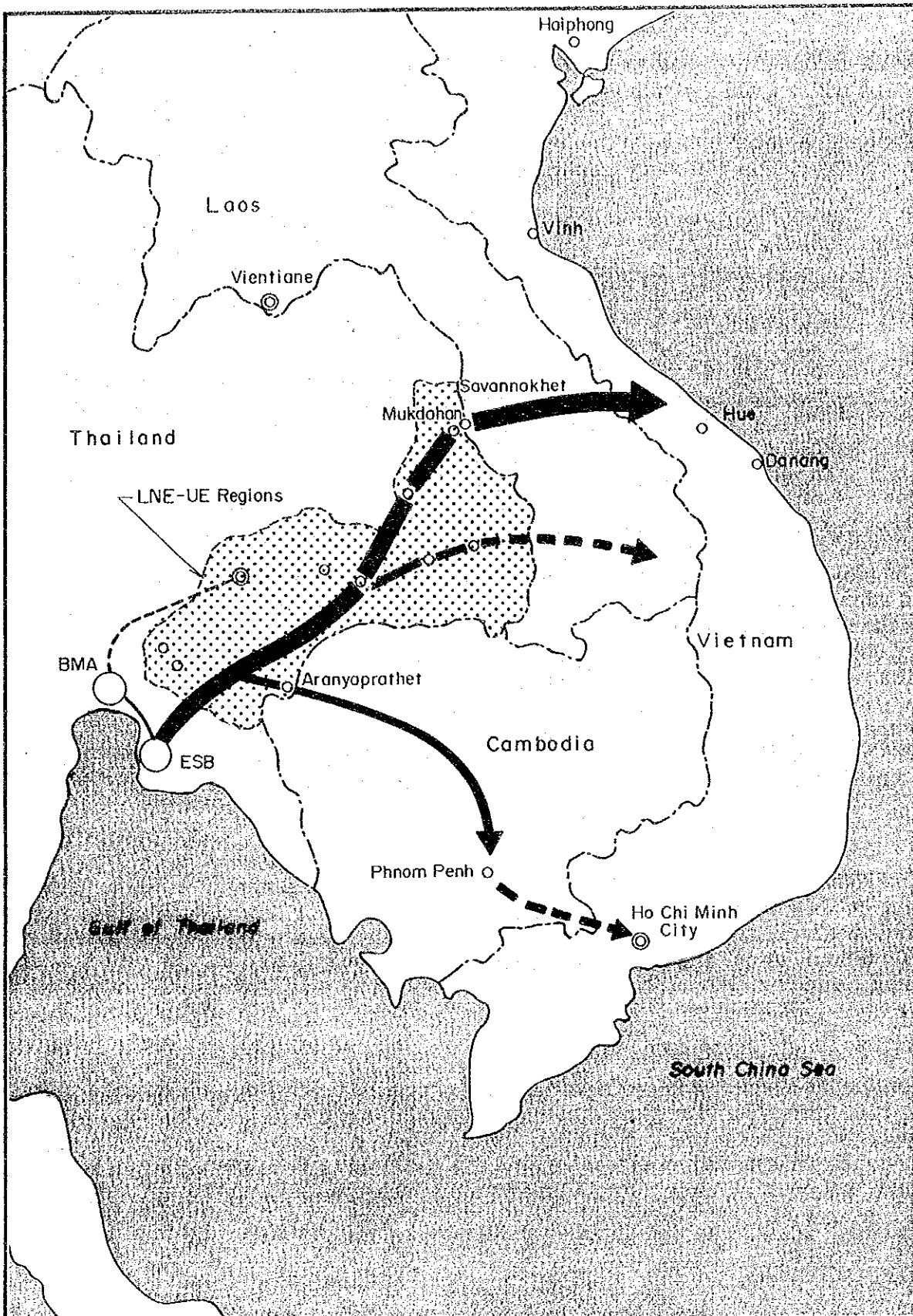


Figure 5.8
New Indochina Gateway Road

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(4) International airport establishment

The LNE-UE regions need at least one international airport within its boundaries. While the existing airports at Nakhon Ratchasima and Ubon Ratchathani are improved and a new airport constructed at Buri Ram, a comprehensive study should be carried out to determine functions and facilities to be provided for an international airport and its location, and a staged development plan formulated. An essential prerequisite to make a new international airport feasible is the establishment of the local air services network (project (8) below).

(5) Motorway network development

According to a proposed nationwide motorway network of 4,300 km, the following motorways are proposed for the Study Area.

- ESB to Nong Khai motorway,
- BMA to Ubon Ratchathani motorway, and
- BMA to Aranyaprathet motorway.

(6) Regional truck terminals

Regional truck terminals should be established at Nakhon Ratchasima and Ubon Ratchathani to increase the freight transport capacities of the Study Area. Berths, platforms, temporary storage and other facilities will be provided.

(7) Railway improvement

The existing SRT northeastern lines should be improved with double-tracking, improved signalling and telecommunication, and slight route re-alignment in some sections. Electrification will further improve their competitive advantage against road transport. The section up to Nakhon Ratchasima should be double-tracked first.

(8) Local air services network development

Air services to the Study Area should link major urban centers within the Study Area and also link them with the Indochina countries. This will enable one day round trip from any major urban center in the Study Area to the BMA and the ESB and formulate a tourism network by air. The first step will be to allow existing air services to make an additional stop within the Study Area. Additional airports with heliport and/or short runway will also be opened for regular services.

(9) New Mekong bridge

The regional artery can be extended further through Laos and all the way to Vietnam. A bridge between Mukdahan and Savannakhet is a natural choice for an alternative crossing over the Mekong river. A recent study by ADB has confirmed this choice.

5.6 Urban System

5.6.1 Objectives and strategy

(1) Characteristics of urbanization in LNE-UE

Urban population

The proportion of urban population in the Study Area varies between 8 to 12% depending on what is defined as "urban". The former includes only provincial (Muang) and district (Tambon) municipalities. The higher figure is based on the definition that includes sanitary districts, which have a minimum 5,000 population and minimum average population density of 1,000 per km².

Regardless of definition, the level of urbanization is extremely low and largely reflects the very large contribution of agriculture in total employment in the Study Area (83% in 1990). This high proportion of rural population is further supported by the non-agricultural sources of income being outside the Study Area, either in Bangkok or abroad. The temporary migration out of the Study Area thus does not lead to substantial permanent migration to the cities within the Study Area.

Structure of urban system

More than half of the urban population in the Study Area in 1992 was in two Muang municipalities of Nakhon Ratchasima and Ubon Ratchathani (the latter including Warin Chamrap). The rest was fairly evenly distributed among 14 municipalities, each with an average population of 23,000 inhabitants.

The small urban towns are centers of services and input delivery for their rural hinterlands. Agro-processing industry and manufacture of consumer goods for their hinterland appears to be less significant. Their future growth will depend primarily upon the growth of rural incomes.

Nakhon Ratchasima is a trade center for the whole of the Northeastern region. Ubon Ratchathani has a similar function in trade and input delivery, but for a smaller (sub-regional) market.

The growth of manufacturing in Nakhon Nayok, Prachin Buri and Nakhon Ratchasima in recent years is primarily due to expansion of BMA-based industries. The growth in urban population, however, appears to have lagged behind that of jobs as these centers have not developed the requisite housing and urban facilities resulting in a high degree of reliance on workers commuting from the surrounding areas, some of them from villages. A major objective of the urban system development would be to support growth of mature urban communities around these new employment opportunities to discourage both daily commuting over long distances, and age/sex specific seasonal migration of rural workers.

Tourism and traditional regional or national market oriented handicrafts (silk, pottery and jewelry) are another base of the urban growth. Both these functions and the specialized urban centers performing them will be strengthened. A major new element in the growth of urban areas will be trade with Indochina. Not only trading, but also manufacturing based on imported local raw materials and export markets in the neighboring regions of Laos and Cambodia will be undertaken in the Study

Area. Ubon Ratchathani is in a unique position to perform the manufacturing functions while trade will be encouraged from many border towns.

Living conditions in urban areas

The physical infrastructure in urban areas is severely deficient. Only half of the households in municipal areas have tap water. Sewerage network is restricted to few main streets, the pipes are sub-standard and effluent is discharged into the nearest river/stream without treatment. Solid waste disposal services are available in most major municipalities. The frequency of collection and the disposal system at the dumps are mostly inadequate. The telecommunication network is practically non-existing : 5 telephone lines per 1,000 inhabitants compared with 160 in Bangkok.

Electricity and road networks, in contrast, are well developed. The additional investment is needed mainly to accommodate the increase in population.

(2) Objectives of urban development

The urban system development that the LNE-UE master plan aims at has the following three main objectives.

- 1) To promote a pattern of spatial distribution which contributes to the social and economic development within the Study Area;
- 2) To reduce migration out of the Area and reduce the pressure on the BMA; and
- 3) To create cities/towns as attractive places to live in, efficient for the provision of urban services and amenities.

(3) Strategy

The first objective calls for a pattern of city size and location which promotes interaction with rural areas in their hinterland. At the same time, interaction between urban places of similar size is to be encouraged to achieve specialization as called for under the strategy adopted in the current Five Year Development Plan.

Rapid growth of cities and rural towns in the Study Area will also reduce the pressure for migration to the BMA. Decentralization from the BMA, however, will also be supported by promoting relocation from this region. This is already happening in the southern part of the Study Area, in Nakhon Ratchasima and Prachin Buri and to a limited extent in Ubon Ratchathani. The master plan will further support this trend.

The size distribution and choice of urban centers whose growth will be promoted has a strong impact on the quality of urban environment. The master plan also calls for measures at the level of individual settlements to avoid environmental deterioration and creation of an attractive urban environment for the residents.

Development of the urban infrastructure is a key element for improvement of the living conditions in urban areas. It is also the main policy instrument available to the government for leading the pattern of spatial development between different urban centers and within each center. Decisions on location of productive enterprises, on

the other hand, are in the private sector and the government can only induce development through information dissemination, providing physical infrastructure, and through regulatory functions discussed in subsection 5.6.3.

In addition to the physical infrastructure, the standards of living in the Study Area need to be improved through stepping up investments in social infrastructure. The Study Area has a severe deficiency in preventive and community health care facilities, technical training facilities and facilities to support urban development. The latter include transport terminals, communal marketing outlets and centers of information dissemination.

Two sets of policy measures are needed to attain the planned urban system. One set involves central and local government efforts to develop the physical infrastructure and urban land. The other set is regulatory and will both control the direction of development and provide incentives to the private operators.

5.6.2 Urban growth projection

(1) Future pattern of urbanization

A realistic target for the urban growth in the Study Area is to channel all of the natural population growth to cities. Small towns throughout the region will be supported to serve the rural population (health, education, administration and trade), and agriculture, in marketing and processing. Industrial relocation will be encouraged in Nakhon Ratchasima, the two provinces of the Upper East and in Ubon Ratchathani.

Higher level functions to be developed in the Study Area will be located in a central area. Taking into account the new proposed transport links, and overall accessibility for the Study Area, the ideal location will be the route between Buri Ram and Surin. The Study Area will thus have four major concentrations of urban growth : a) Nakhon Nayok/Prachin Buri, b) Nakhon Ratchasima, c) Ubon Ratchathani, and d) the new regional growth center in Buri Ram - Surin.

(2) Projection of urban population

Level of urban population

The projections of urban population are based on changes in non-agricultural employment. The population dependent on each broad sector is calculated from the dependency ratios. It is assumed that all of the incremental population dependent on industry, and 80% of that on services will occur in urban areas. This provides one estimate of the magnitude of growth in urban population until the year 2010.

Distribution of urban population

The projected growth in industrial employment is first broken into its three components : manufacturing, construction and mining. Manufacturing employment is further broken into three components a) footloose international market oriented industries, b) agro-based industries, and c) linkage industries. Almost all of the first will locate in the Upper East region and Nakhon Ratchasima. Ubon Ratchathani will have a small share of these industries. Those in the second groups are assigned to each province on the basis of the projected share of rural population in each

province. Linkage industries are distributed on the basis of the first two groups, but an even larger share is assigned to the major urban centers to simulate the effect of agglomeration economies which are a critical locational determinant for such industries.

The bulk of incremental employment during the plan period will be in services. For locational distribution, the projected service population is broken into four components. These are a) trade, b) personal services, c) business services, and d) others. The tourism component of (b) is assigned to the centers earmarked for tourism development. The rest in this group is distributed on the basis of total income in each province, and subsequently each district. All business services are assigned to the four major growth centers in proportion to their total employment. The rest is assigned on the basis of total population.

Projected population

Urban population was projected from the point of view of promoting a pattern that is conducive to further growth of the Study Area. This emphasizes inter-settlement linkages within the Study Area and a growth pattern that counters the polarizing impact of the BMA. Projection results are summarized in subsection 3.3.3 (details in Sector Report).

5.6.3 Development projects and support measures

Measures to support the projected urban growth consist of various projects to improve urban infrastructure and utilities, and policy measures. Most urban projects will continue to be planned and implemented by line agencies of the central government through its established local planning and development system. A new type of project and implementing system is proposed under the integrated urban development project, and measures to strengthen local administration for urban planning and development are recommended.

(1) Integrated urban development

This project will be implemented for selected urban centers one after another. A package of component projects, such as water supply, sewerage, by-pass road and truck terminal, will be prepared for improving the urban infrastructure and utilities to meet specific needs of an urban center to fulfill its expected roles. Components of packages are different depending on urban centers with different roles expected in the future. Components related to improving the urban environment will be increasingly more important in a few larger cities.

The project will also be conducive to improving local planning and management capabilities of municipalities. Development funding and financial management will be examined, including cost recovery for some component projects by user charges as well as expansion of financial capacity at large.

Preparation of implementable plans, including both component projects and measures for improving municipal management, should be the responsibility of respective municipalities, but they should be technically supported by the proposed PMU (Section 6.4). Selection of a few urban centers for initial implementation would depend on their project preparation efforts and implementing capabilities. Candidates for initial implementation include Nakhon Ratchasima, Ubon Ratchathani, Mukdahan

and Aranyaprathet. The project will become replicable to other urban centers with respect to implementing arrangements including funding.

A key of realizing planned urban development is land acquisition for facilities to be provided by the public sector. Relocation of existing industries from city centers according to detailed landuse plans would provide an opportunity to acquire the evacuated lands and develop them for public purposes.

(2) Local planning and management.

There is practically no local control over urban development. Most local services are the responsibilities of national line agencies : water, sanitation, road construction, locational decisions, and town planning/zoning. For effective planning, the short-term emphasis would have to be placed on coordination between national line agencies. The national administrative structure for this is the office of the governor of province with regional level coordination provided by NESDB.

In the medium to long term, local administrations need to be strengthened to carry the full responsibility for town planning, and provision of basic infrastructure. This issue is currently debated nationally. An immediate short-term measure that the government can take is to increase the proportion of funds transferred to local administrations under the "non-specific" category as opposed to those which are earmarked for specific projects. The local governments would be free to allocate these funds to projects as they deem desirable.

In the medium term, new drastic measures are needed to strengthen the local administrations financially. Proposals vary from increasing the rates for the existing local taxes (mostly property and business taxes), and improving collection efficiency, to introducing new taxes, and transferring some of the revenue from existing taxes from the central to local governments.

All municipalities in the Study Area have an outline map. This map delineates the present municipal boundaries, and general plan boundaries. These boundaries include a fairly large area with resulting low urban densities. Two further steps need to be taken. The first is to detail the land use types, indicate the planned infrastructure within the municipal boundaries, and insure that developments actually conform to the plan.

The second is to prevent the over spill along the roads, (outside the municipal boundaries) which leads to the ribbon type of development. This would call for strict zoning regulations for the general plan boundary with clear restrictions on the type of development that may be allowed. This, in combination with production of developed urban lots (having road access and basic utilities) is a prerequisite for creating a compact, but not necessarily high density, urban form which allows for an efficient pattern of urban infrastructure provision and is conducive to creating a desirable urban atmosphere free from noise, fumes, and through traffic, where most activities are within walking or cycling distance.

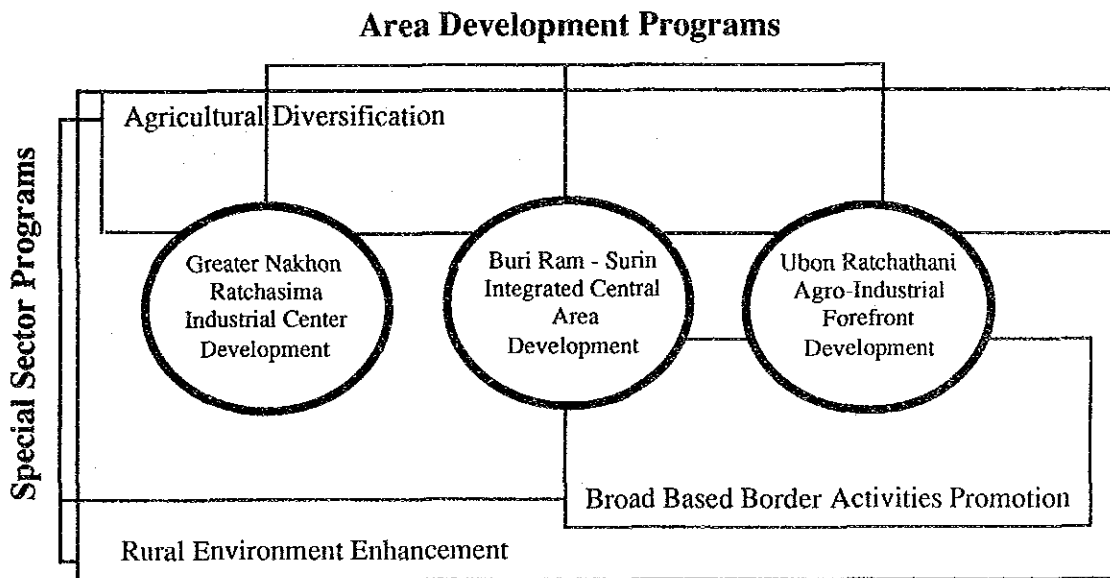
CHAPTER 6

LNE-UE REGIONAL DEVELOPMENT PLAN

The LNE-UE regional development plan has been formulated by integrating the sector development plans presented in Chapter 4 and Chapter 5 within the frameworks for the balanced development described in Chapter 3. The plan consists of development projects and institutional measures to complement the project implementation. Core projects have been designated, which would be essential to realize the planned development. They can be classified into regional/inter-regional projects and local projects. The former include both inter-provincial projects and sets of local projects located in several provinces and packaged for integrated implementation (Section 6.1).

Most local projects are packaged into three area development programs (Section 6.2) and three sector programs (Section 6.3) combining also project specific institutional measures. These programs are complementary to one another to realize the overall regional development (Figure 6.1). Other sector specific institutional measures are contained in respective sector plans. Measures for human development are highlighted (Section 6.4). Development administration to facilitate the implementation of the Master Plan is recommended (Section 6.5).

Figure 6.1 Three Area Development Programs and Three Special Sector Programs



6.1 Regional/Inter-Regional Projects

6.1.1 Designation of core projects

Nine regional/inter-regional projects have been designated. Three of them are completely new, formulated through master planning: regional artery establishment

(or new Indochina gateway road), local air services network development, and small pumping reservoirs development. Four projects represent extension of on-going efforts: railway improvement, route no.24 improvement, Lam Thakong pumped storage power generation, and Pak Mun hydropower.

The remaining two have been planned by implementing agencies and endorsed by the master plan: Second Mekong bridge, and Phanom Dong Rek water resources development.

6.1.2 Implementation phasing

Implementation phasing of the core regional/inter-regional projects is given in Table 6.1. The Phamon Dong Rek water resources development project will be implemented in two stages as planned by RID. Implementation of the Pak Mun hydropower and the Lam Thakong pumped storage power generation would follow the EGAT plan. Implementation phasing of other projects is outlined below.

An initial link between Sa Kaeo and Buri Ram/Surin will be established in Phase I for the regional artery establishment project as well as improvement of route No. 2169. The artery would be extended to the ESB in Phase II together with improvement of other sections. It would become an international artery during Phase II.

Detailed design of the Bangkok - Nakhon Ratchasima double tracking will be prepared in Phase I for the railway improvement, to be followed by initial implementation. Double tracking will continue through Phase II and Phase III. Also during Phase II, improved signaling and telecommunication will be introduced, and an inland container depot established in connection with the Nakhon Ratchasima station.

Priority sections of route No. 24 will be improved in Phase I as planned by DOH, and other sections will be improved subsequently. A feasibility study of the Second Mekong bridge will be conducted in Phase I and its construction will start during Phase II following detailed design for completion in early part of Phase III. The local air services network will develop in steps and service links to the Indochina countries will be established during Phase II.

Identified schemes of the small pumping reservoirs development will be implemented in Phase I. River basin studies as recommended by the master plan will be carried out also in Phase I to identify more sites for implementation through Phase II and Phase III.

6.2 Area Development Programs

6.2.1 Development structure of LNE-UE

Development axes/arteries

Three development axes/arteries are important for the development of the Study Area (LNE-UE). The east-west axis connecting the two major urban centers of Nakhon Ratchasima and Ubon Ratchathani will be strengthened with the expansion of functions of these centers. The north-south axis leading from the ESB, through Prachin Buri to Nakhon Ratchasima and the further north will develop naturally to constitute the Northeast Industrial Development Corridor. A new regional artery will

Table 6.1 Implementation Phasing of Regional/Inter-Regional Projects

No.	Core Project	Phase I (~ 1996)	Phase II (1997 - 2001)	Phase III (2002 - 2010)
R.1	Regional artery establishment (New Indochina gateway road)	Sa Kao - Buri Ram/Surin link Route no.2169	Extension to the ESB Improvement of other sections	Further improvement of other sections
R.2	Railway improvement	D/D and initial implementation of Bangkok - Nakhon Ratchasima double tracking	Continuation of double tracking, improved signaling and telecom. Inland container depot	High speed train - Stage I
R.3	Route no.24 improvement	Improvement of sections as planned by DOH	Improvement of other sections	Upgrading to higher standards
R.4	Second Mekong bridge	F/S	D/D and initial implementation	Completion
R.5	Local air services network development	Establishment of network within LNE-UE	Links to the Indochina	
R.6	Small pumping reservoirs development	Implementation of identified schemes River basin studies to identify more sites	Continuation of river basin studies and implementation	Continuation of implementation
R.7	Phanom Dong Rek water resources development	Completion of 1st stage Initiation of 2nd stage	Completion of 2nd stage	
R.8	Lam Thakong pumped storage power generation	Stage I implementation (250 MW)	State II implementation (250 MW x 3)	
R.9	Pak Mun hydropower	Implementation	Completion	

be established to serve the central and the northeastern parts of the Study Area to change strategically the development structure of LNE-UE.

Strategic development areas

Three development areas are defined corresponding to the three development axes/arteries, where development efforts should be concentrated. First, the city of Nakhon Ratchasima will continue to provide a driving force for the LNE-UE development as a regional center for various industrial and trade activities. The city alone, however, cannot counterbalance the huge agglomeration of the BMA located only some 250 km away. A larger area is defined as a development area, where various activities would complement one another and strengthen the functions of the provincial capital. The link with the ESB will be further strengthened (Figure 6.2 (a)).

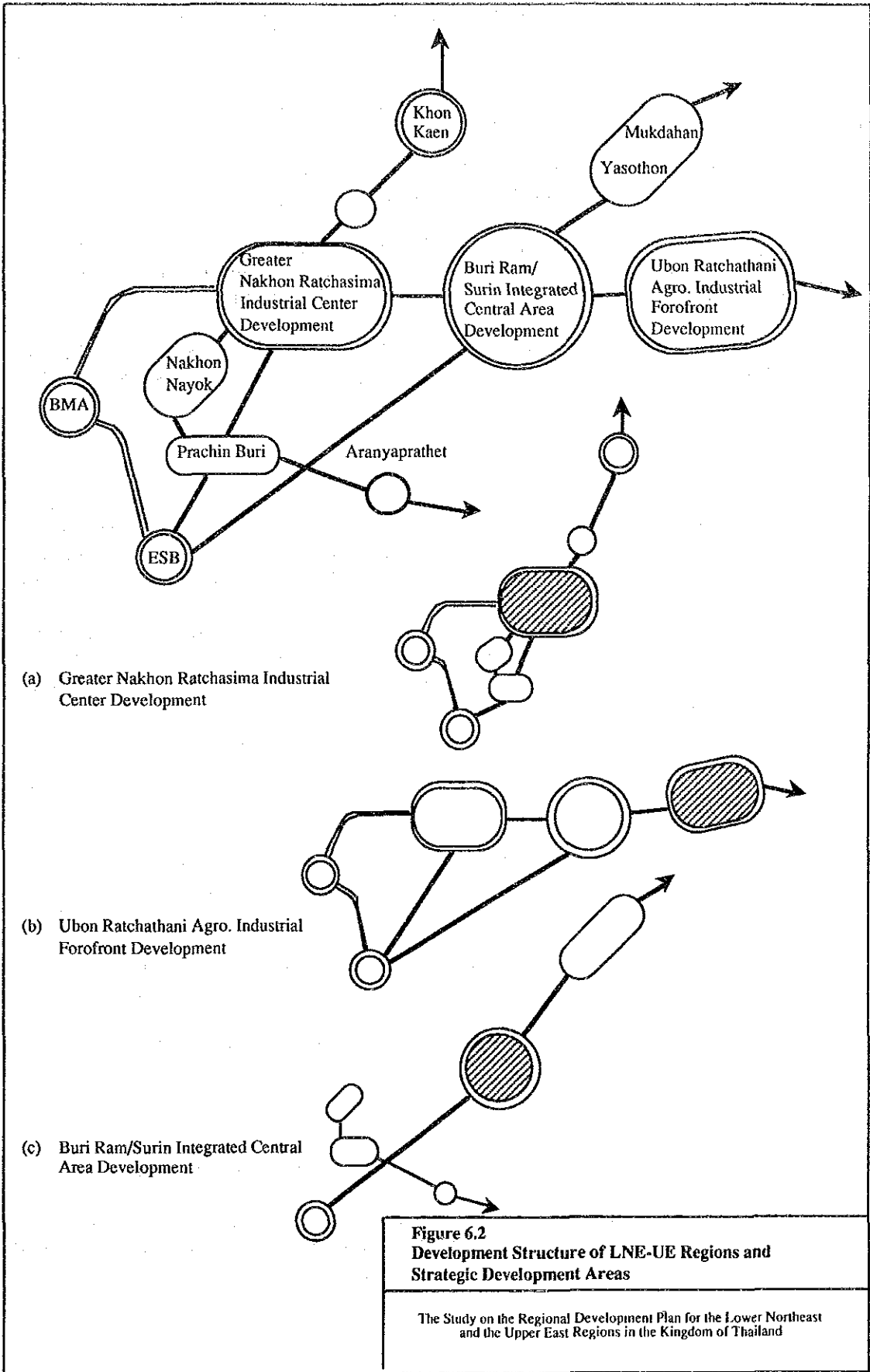
Second, the city of Ubon Ratchathani together with Warin Chamrap constitutes another urban agglomeration to be utilized to strengthen the east-west development axis. It is a forefront for the development of the interior and increasing interactions with the Indochina countries. A development area is defined covering its hinterland including Si Sa Ket (Figure 6.2 (b)).

Third, the central part of the lower Northeast along the new regional artery is critically important for the better balanced development of the Study Area. An extensive area around the cities of Buri Ram and Surin is defined as another development area to uplift the living standard of this generally rural area (Figure 6.2 (c)).

Area development programs

Area development programs have been formulated for the selected development areas that are strategically important for the LNE-UE regional development. They are (1) Greater Nakhon Ratchasima Industrial Center Development, (2) Ubon Ratchathani Agro-Industrial Forefront Development, and (3) Buri Ram - Surin Integrated Central Area Development. These programs are described below with their objectives, characterization, strategy and component projects/programs taken from the sector plans.

It is expected that relocation of industries from Bangkok will continue into Prachin Buri and Nakhon Nayok. This constitutes another growth area, but it would need to be planned with reference to changes occurring in the BMA. Mukdahan and Yasothon will develop in connection with both the Ubon Ratchathani Agro-Industrial Forefront Development and the Buri Ram - Surin Integrated Central Area Development.



6.2.2 Greater Nakhon Ratchasima Industrial Center Development

(1) Objectives

Objectives of this area development program are the following.

- 1) To strengthen the functions of the Nakhon Ratchasima city as the major growth center and the regional industrial and trade center;
- 2) To make the Greater Nakhon Ratchasima Area large enough to counter-balance the agglomeration of the BMA with the development of secondary urban centers to complement the functions of the capital city; and
- 3) To induce the development of hinterland rural areas by improving productive as well as physical links between the urban centers and the rural areas.

(2) Characterization

Spontaneous development of this area will continue without any intervention, centering on the Nakhon Ratchasima city. Such development will be led primarily by footloose, labor-intensive and export-oriented industries located mainly in industrial estates. This type of industries, while generating large number of employment opportunities, may not induce much other industries, and the surrounding areas would remain relatively less developed. Therefore, the industrialization strategy for the Study Area is to encourage engineering and machinery industries, including electrical and transport equipment, which would develop a wider spatial linkage. Nakhon Ratchasima may eventually become a "Detroit of Thailand" (subsection 4.2.1).

Several secondary urban centers will complement Nakhon Ratchasima for some agro-processing and other local resource based industries. They will benefit from the engineering and machinery industries in Nakhon Ratchasima, which will support agricultural modernization and provide processing equipment and materials. The area will be linked with the Khao Yai area for research and development for high technology, complementary to the technopolis in Nakhon Ratchasima.

Diverse activities will be promoted in hinterland rural areas linked with activities in the urban centers for processing and marketing of agro-related products and procurement of capital and intermediate goods. They include livestock (both dairy and meat), poultry, sericulture, silk weaving and textiles, oil crops, raw edible oil extraction and feed mills.

(3) Strategy

The strategy for this area development program consists of the following.

- 1) Improvement of urban infrastructure and utilities to improve comparative advantage for the location of footloose, labor-intensive and export-oriented industries.

This is to promote further the on-going location of this type of industries in and around the Nakhon Ratchasima city. Supply reliability and stability of electricity will have to be improved, water supply and telecommunication services much expanded, and sewerage installation accelerated. Need for solid waste disposal will also become acute.

- 2) Technology development and skill training for engineering and machinery industries and other linkage industries.

To develop the engineering and machinery industries as a backbone for the industrialization of the Study Area, technology development and skill training hold a key. Also subcontracting and input supply linkages should be developed between large industries and many small ones.

- 3) Improvement of links between urban centers and between urban and rural areas.

To further encourage economic links between industries, and service establishments located in different urban centers, physical links between them will be improved. To support processing of new agricultural produce, links between urban and rural areas will be improved.

- 4) Encouragement of new agricultural activities to expand the local resource base.

Agricultural production in rural areas will have to be expanded, especially for new agricultural products that can be processed in nearby urban centers.

- (4) Development projects

Five core projects formulated in different sectors will support the industrial development of this area development program. Phasing of implementation is indicated in Table 6.2.

The Nakhon Ratchasima integrated urban development together with natural gas pipeline extension and co-generation system correspond to strategy (1). The Nakhon Ratchasima integrated urban development will cover the regional truck terminal, commerce and industry plaza complex and automobile test course as well as urban utilities and infrastructure.

The Nakhon Ratchasima industrial modernization (or small industry district) and the Khao Yai resort and research development correspond to strategy (2). For strategy (3), this area development program will benefit from the regional projects such as the railway improvement and route no.24 improvement. Some other regional projects will contribute to strategy (1).

Agricultural development in rural areas will be supported by the Agricultural Diversification Program described in subsection 6.3.2 in line with strategy (4). The Rural Environment Enhancement Program described in subsection 6.3.3 will also support primary production, processing and related services activities in the rural areas.

Table 6.2 Implementation Phasing of Greater Nakhon Ratchasima Industrial Center Development

No.	Core Project	Phase I (~ 1996)	Phase II (1997 - 2001)	Phase III (2002 - 2016)
1.1	Nakhon Ratchasima integrated urban development - Regional truck terminal - Commerce and industry plaza complex - Automobile test course	<ul style="list-style-type: none"> • Plan formulation and initial implementation (drainage, sewerage etc.) • Implementation • Implementing arrangement by public-private partnership 	<ul style="list-style-type: none"> • Full scale implementation (water supply expansion, new by-pass, solid waste etc.) • Implementation • Implementing arrangement by public-private partnership 	<ul style="list-style-type: none"> • Continued implementation and plan reformulation
1.2	Nakhon Ratchasima industrial modernization (small industry district)	<ul style="list-style-type: none"> • Initial establishment following plan for project no.1.1 	<ul style="list-style-type: none"> • Expansion 	<ul style="list-style-type: none"> • Implementation
1.3	Natural gas pipeline extension	<ul style="list-style-type: none"> • Implementation 		
1.4	Co-generation system	<ul style="list-style-type: none"> • F/S and D/D 	<ul style="list-style-type: none"> • Implementation 	
1.5	Khao Yai resort and research development	<ul style="list-style-type: none"> • Plan formulation and implementing arrangement 	<ul style="list-style-type: none"> • Initial implementation 	<ul style="list-style-type: none"> • Expansion

(5) Implementation plan

Those projects already planned by implementing agencies should be implemented in the nearest future. They are the natural gas pipeline extension and regional truck terminal as well as various urban projects and road projects.

The Nakhon Ratchasima integrated urban development project should be formulated in Phase I for subsequent implementation during Phases I through III. Important components include water supply, electricity, telecommunications, sewerage and solid waste management. As Nakhon Ratchasima is foreseen to face the most serious water shortage (subsection 5.2.2.), water resources need to be fully explored and developed efficiently, including groundwater. Also reduction of losses and cost recovery by proper user charges should be part of this project. The latter would provide an opportunity to improve the municipal management, including development funding and financial management. Project planning and implementation monitoring would be other important functions not only of Nakhon Ratchasima but of any major municipalities. This project may serve as a model case for planning and implementing such integrated urban development projects under a new project planning and funding system.

Studies and other implementing arrangements should be prepared during Phase I for the projects to be implemented in subsequent phases. In particular, a formula for a public private partnership may be established for the commerce and industry plaza complex project. The local government may offer land for the project site, and public information and one-stop service center may be established and operated by BOI. Offices of traders, suppliers and distributors will be established by the private sector with other related facilities.

A basic plan for the Khao Yai resort and research development should be drafted, mustering efforts of private enterprises and government agencies. The plan should cover not only facilities to be included and site selection but also a range of activities and subjects to be dealt with in the Khao Yai area in view of the functions of the technopolis in Nakhon Ratchasima, and existing and expected industries in the Study Area and the ESB.

6.2.3 Ubon Ratchathani Agro-Industrial Forefront Development

(1) Objectives

Objectives of this area development program are defined as follows.

- 1) To strengthen the functions of the Ubon Ratchathani city as another growth center of LNE-UE; and
- 2) To develop the Ubon Ratchathani and surrounding areas as a forefront of various agro-industrial activities that are emerging as economic interactions increase with the Indochina countries.

(2) Characterization

Ubon Ratchathani with Warin Chamrap on the other side of the Mun river has the agglomeration of urban population and economic activities almost comparable to the agglomeration in the Nakhon Ratchasima city. Capitalizing on this, this urban center

will be further developed as a sub-regional center with multiple functions. In particular, it will be a center for trade and commercial activities, increasingly so as economic links with the Indochina are strengthened. It will continue to offer locations for consumer goods, agro-processing and other industries. It will have secondary importance as an alternative location for industries to be relocated from the BMA, including water-intensive ones. Airport-oriented, high value-added products manufacturing will be attracted, too.

Si Sa Ket is included in this development area to complement the functions of Ubon Ratchathani. It will be specialized as a center for livestock related activities, providing feed and other input and processing for dairy and meat products.

Agricultural development in the hinterland rural area holds a key for the success of this area development program. In particular, livestock activities and diversified crops for processing should be much expanded. The provinces of Ubon Ratchathani and Si Sa Ket have the largest areas of sandy and skeletal soil presently used mostly for paddy. These are potential areas for livestock development with cattle. Also these provinces have the largest areas that are potentially suited to field and tree crops but presently used for other purposes. Thus crop diversification in favour of those crops to be processed is most promising in this development area.

This development area includes border areas with Laos and Cambodia. Broad based border activities should be promoted for commodity trade, export processing, tourism, financial transactions, skill training, and research and development activities. The area will also be the center for hinterland tourism linked to tourism objects in Laos and Cambodia (subsection 4.3.3).

(3) Strategy

The strategy for this area development program consists of the following.

- 1) Improvement of urban facilities to support the specialized functions of Ubon Ratchathani.

Important functions of Ubon Ratchathani include those related to broad based border activities and an information center. The latter will serve not only the Study Area but also the Indochina.

- 2) Land use conversion emphasizing livestock and crop diversification.

Extensive areas in this development area are suited more to livestock and field/tree crops than to paddy as described above. Land use conversion for these activities would expand the resource base for agro-processing.

- 3) Water resources development and management

This area is relatively rich in water resources endowment. Flood control and drainage are more important for lowland agriculture than irrigation. Future water use will significantly change to support water-intensive industries, cultivation of high value-added crops under irrigation and other urban/industrial uses.

(4) Development projects

New agricultural activities in the rural areas will be supported by the Agricultural Diversification Program and the Rural Environment Enhancement Program described in subsections 6.2.2 and 6.2.3, respectively. Five core projects are contained in this program. Development phasing is indicated in Table 6.3.

The Ubon Ratchathani integrated urban development project, "Teleport", and border trade center correspond to strategy (1). The regional truck terminal and commerce and industry plaza complex will also be covered by the Ubon Ratchathani integrated urban development as well as urban utilities and infrastructure. The "Agropolis" will support strategy (2), and the Lam Don Yai/Huai Tha multipurpose water resources development will support strategy (3).

This area development program will benefit from the regional projects. The small pumping reservoir and Phanom Dong Rek water resources development will contribute to strategy (2) and (3).

(5) Implementation plan

Several road projects and various urban projects already planned by implementing agencies and contained in the development programs for the Seventh Five Year Plan should be implemented without delay. The same applies to the Pak Mun dam and hydropower development.

The Ubon Ratchathani integrated urban development project is a key project for this area development program. It will be formulated during Phase I for subsequent implementation through Phase III. Important components include water supply and sewerage, electricity, telecommunications, urban roads and drainage, municipal slaughterhouse, cold storage and solid waste disposal.

A comprehensive study should be carried out in Phase I for water resources development in the Lam Don Yai and the Huai Tha river basins. It will include feasibility studies of priority multipurpose projects. Implementation of these projects will follow in Phase II as well as feasibility studies of other projects newly formulated.

Other core projects should also be studied in Phase I for implementation in Phase II. A plan for the border trade center will be prepared, clarifying functions and facilities to be included. Detailed system configurations will be determined for the "Teleport". The telecommunication component of the Ubon Ratchathani integrated urban development project should be consistent with such system configurations.

A development plan for the "Agropolis" may be worked out by a private enterprise, but its implementation will be by a public-private partnership. The local government may offer land for the project site, and establish and operate a quality control center under the direction of the central government.

Table 6.3 Implementation Phasing of Ubon Ratchathani Agro-Industrial Forefront Development

No.	Core Project	Phase I (~ 1996)	Phase II (1997 ~ 2001)	Phase III (2002 ~ 2010)
2.1	Ubon Ratchathani integrated urban development - Regional truck terminal - Commerce and industry plaza complex	<ul style="list-style-type: none"> Plan formulation and initial implementation (urban roads, drainage etc.) F/S Implementing arrangement by public-private partnership 	<ul style="list-style-type: none"> Full scale implementation (water supply, sewerage etc.) Implementation Implementation 	<ul style="list-style-type: none"> Continued implementation and plan reformulation
2.2	"Teleport"	<ul style="list-style-type: none"> Determination of detailed configurations and establishment of base station 	<ul style="list-style-type: none"> Installation of satellite gateway 	<ul style="list-style-type: none"> Full establishment of "Teleport"
2.3	"Agropolis"	<ul style="list-style-type: none"> Planning and implementing arrangement by public-private partnership 	<ul style="list-style-type: none"> Establishment of "Agropolis" 	<ul style="list-style-type: none"> Expansion and full-scale operation
2.4	Border trade center development	<ul style="list-style-type: none"> Planning and initial implementation 	<ul style="list-style-type: none"> Expansion with full functions 	
2.5	Lam Don Yai/Huai Tha multi-purpose development	<ul style="list-style-type: none"> Master planning and F/S of priority projects 	<ul style="list-style-type: none"> Implementation of priority projects and F/S of others 	<ul style="list-style-type: none"> Implementation of other projects

6.2.4 Buri Ram - Surin Integrated Central Area Development

(1) Objectives

Objectives of this area development program have been established as follows.

- 1) To establish a new core of development in the least developed central part of the Lower Northeast;
- 2) To create a large number of employment opportunities in various rural industries and related services throughout the area to increase income levels of rural populace and thus minimize the drift of rural people into larger cities; and
- 3) To enhance the land and water environment of the generally dry central part of the Lower Northeast.

(2) Characterization

At present, there are a few characteristic industries in the area : wigs manufacturing in Buri Ram, and artificial flower manufacturing and silver handicraft in Surin. These are labor intensive and export oriented. Once the link between this area and the ESB is improved, more industries of this type will establish in the area. Improved links with the Indochina may expand markets and raw materials base. Some of the high value-added products of light industries may be exported directly from the new international airport in Buri Ram.

These industries would be distributed widely in rural areas rather than concentrating in major urban centers. This would create a more dispersed population distribution with many small rural industrial centers surrounded by greenery and productive land. The city of Surin will be a center for these rural industries providing technical and managerial skills. It will also be a center for technical cooperation with Laos and Cambodia.

Buri Ram will be a gateway and tourism center for the Study Area, served by the new international airport and the new regional artery linking the area with the ESB and the Indochina. Water resources are relatively rich in Buri Ram. With better management of land and water environment, this dry and relatively unproductive area will be turned into productive land with plenty of greenery.

(3) Strategy

The strategy for this area development program consists of the following.

- 1) Establishment of new physical links with the BMA, the ESB and the Indochina.

New physical links should be established with the BMA by air, the ESB by the new regional artery and the Indochina both by air and by the regional artery.

2) Water resources development and management

Despite a general belief, Buri Ram and Surin are relatively rich in water resources as far as total endowment is concerned (subsection 5.2.2). However, water storage is difficult due to relatively flat terrains. Maximum utilization of available storage facilities and additional storage spaces is of utmost importance.

3) Skill training for various rural industries

The area has abundant trainable work force, and skill training is a key to success of many rural industries. Continuous skill training and development would help the area to maintain competitive edge over the neighboring countries where some industries of lower skill requirements would shift their production base.

4) Afforestation, on-farm tree planting, tourism resource upgrading and city beautification.

Original forest areas along the southern borders of Buri Ram and Surin have been largely converted to field crops. Small reforestation areas also exist. Afforestation and on-farm tree planting should be encouraged in these areas to enhance land and water environment. This, together with tourism resource upgrading and city beautification will enhance the tourism value of the area.

(4) Development projects

Four core projects constitute the area development program together with the regional projects. Phasing of implementation is shown in Table 6.4.

The Buri Ram international airport and the two regional projects, viz. regional artery establishment and local air services network development, support strategy (1). Strategy (2) is supported by the Lam Nam Chi/Lam Plai Mat multipurpose development. The Northeast industrial promotion sub-center (or future Indochina industrial promotion center) corresponds to strategy (3). Strategy (4) is supported by the Buri Ram - Surin twin city development and various projects to be formulated through master planning for the Lam Nam Chi/Lam Plai Mat multipurpose development. The latter include the "Green wedge" development, elephant park establishment, and Khmer ruins upgrading.

Rural industries and related services will be supported also by the Rural Environment Enhancement Program described in subsection 6.2.3.

Table 6.4 Implementation Phasing of Buri Ram - Surin Integrated Central Area Development

No.	Core Project	Phase I (~ 1996)	Phase II (1997 - 2001)	Phase III (2002 - 2010)
3.1	Buri Ram international airport	<ul style="list-style-type: none"> • Implementation as a local airport 	<ul style="list-style-type: none"> • Expansion to an international airport 	
3.2	Northeast industrial promotion sub-center	<ul style="list-style-type: none"> • Plan formulation and initial implementation 	<ul style="list-style-type: none"> • Expansion to serve the Indochina 	
3.3	Lam Nam Chi/Lam Plai Mat multi-purpose development <ul style="list-style-type: none"> - "Green wedge" development - Elephant park establishment - Khmer ruins upgrading 	<ul style="list-style-type: none"> • Master planning and F/S of priority projects • Implementation of identified small pumping reservoirs • Reforestation following M/P • Identification of site by M/P • Continuation of restoration and tree planting 	<ul style="list-style-type: none"> • Implementation of priority projects • F/S of other projects • Continuation • Implementation • Khmer heritage museum 	<ul style="list-style-type: none"> • Continuation
3.4	Buri Ram - Surin twin city development	<ul style="list-style-type: none"> • Plan formulation including water supply expansion 	<ul style="list-style-type: none"> • Implementation 	<ul style="list-style-type: none"> • Continuation

(5) Implementation plan

Implementation of on-going projects planned by implementing agencies should be expedited. They include the Buri Ram international airport, Khmer ruins restoration program, urban projects in Buri Ram and Surin, and small road projects.

A comprehensive study should be carried out in Phase I for the Lam Nam Chi and the Lam Plai Mat multipurpose development project. Additional sites for water storage in large scale are practically non-existent in these river basins. Therefore, the small pumping reservoirs development project formulated at this time should be elaborated on and additional sites identified. Groundwater exploration will also be part of the study. Implementation of these projects will start also in Phase I and continue through Phases II and III.

Areas suitable for reforestation and economic forests will also be identified through this basin study as well as site for the new elephant park. Implementation of the "Green wedge" development project will follow immediately and the elephant park establishment project in Phase II. Buri Ram - Surin twin city development should be planned in Phase I and implemented through Phase III.

The Northeast industrial promotion sub-center will be planned for initial implementation in Phase I to serve the Study Area. It will be expanded in stages to serve Laos and Cambodia.

Area Development Programs

Greater Nakhon Ratchasima Industrial Center

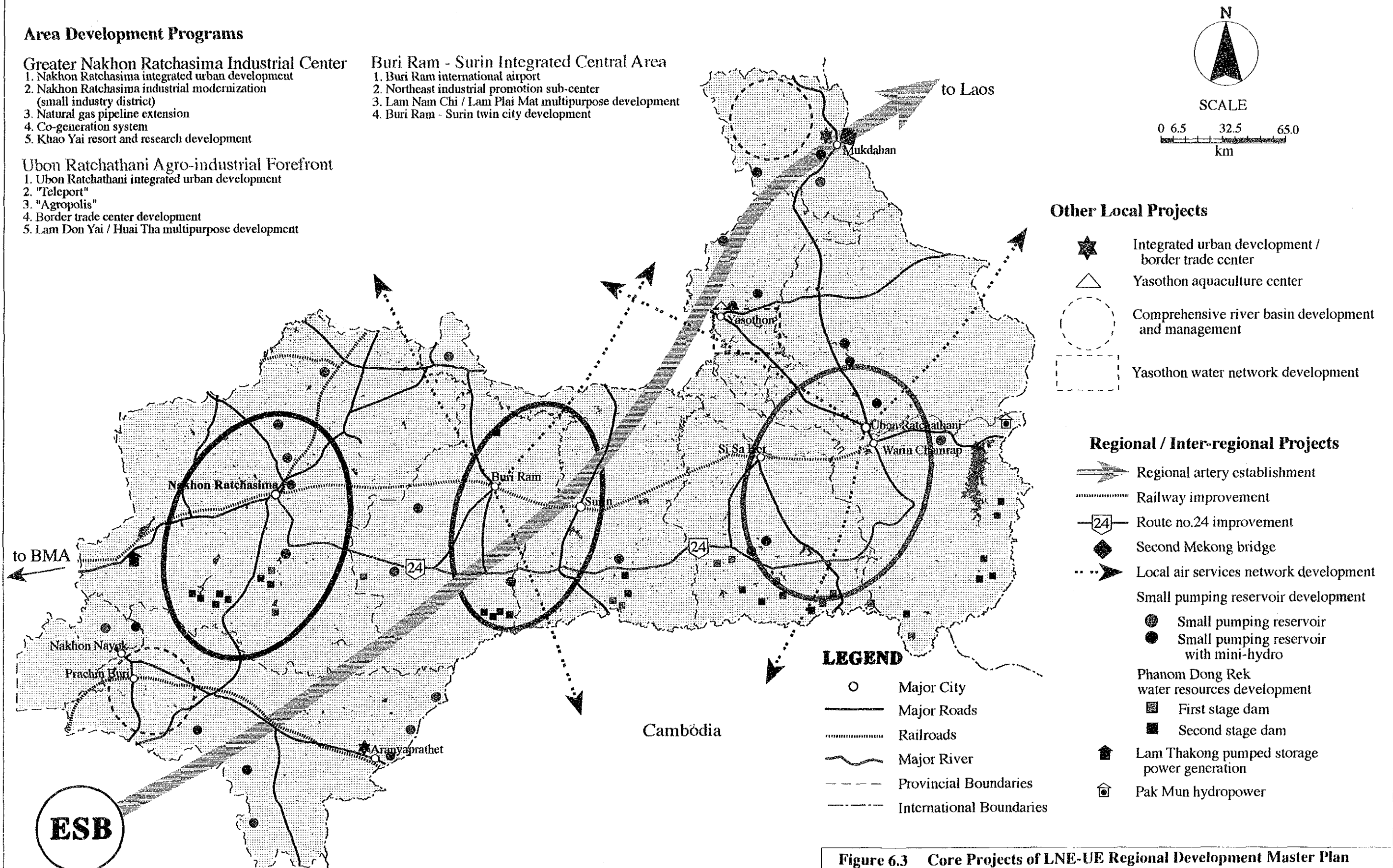
1. Nakhon Ratchasima integrated urban development
2. Nakhon Ratchasima industrial modernization (small industry district)
3. Natural gas pipeline extension
4. Co-generation system
5. Khao Yai resort and research development

Ubun Ratchathani Agro-industrial Forefront

1. Ubun Ratchathani integrated urban development
2. "Teleport"
3. "Agropolis"
4. Border trade center development
5. Lam Don Yai / Huai Tha multipurpose development

Buri Ram - Surin Integrated Central Area

1. Buri Ram international airport
2. Northeast industrial promotion sub-center
3. Lam Nam Chi / Lam Plai Mat multipurpose development
4. Buri Ram - Surin twin city development



Other Local Projects

- ★ Integrated urban development / border trade center
- △ Yasothon aquaculture center
- Comprehensive river basin development and management
- Yasothon water network development

Regional / Inter-regional Projects

- ➔ Regional artery establishment
- ⋯⋯⋯ Railway improvement
- 24 Route no.24 improvement
- ◆ Second Mekong bridge
- ⋯⋯➔ Local air services network development

- Small pumping reservoir
- Small pumping reservoir with mini-hydro
- Phanom Dong Rek water resources development
- First stage dam
- Second stage dam
- ⬆ Lam Thakong pumped storage power generation
- ⬆ Pak Mun hydropower

LEGEND

- Major City
- Major Roads
- ⋯⋯⋯ Railroads
- ~ Major River
- - - Provincial Boundaries
- - - International Boundaries

Figure 6.3 Core Projects of LNE-UE Regional Development Master Plan

The Study on the Regional Development Plan for the Lower Northeast and the Upper East Regions in the Kingdom of Thailand

Note : Basic elements of this map composition were derived from the Geographic Information System (GIS) Database developed in the study.

ESB

