CHAPTER 1

INTRODUCTION

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1-1 STUDY OBJECTIVES

One of the major stresses in the current National Economic and Social Development Plan (1977 - 1981) is to reduce the economic disparities among regions. In line with this strategy, efforts have been made to decentralize basic infrastructures and social services to stimulate the economic activities in the less developed regions. It is envisaged that the next Five-Year Plan (1982 - 1986) will continue to materialize the same strategy as before.

In the Northern Region, further development of rural infrastructures is demanded in order to attain the balanced regional development putting emphasis on the agricultural diversification together with the moderate urbanization. In this context, it is quite important to establish sufficient networks of roads which link socio-economic centers each other and access to isolated areas with high development potentials.

Under such background, the Department of Highways (DOH) has contemplated to conduct a study to identify the further requirement of road development in the Northern Region aim-

ing at, in particular, picking up of priority projects to be enlisted in the next Five-Year Plan. In response to the request by the Royal Government of Thailand, the Government of Japan decided to cooperate with the Thai Government in carrying out of the said study (hereinafter referred to as the Study). The Japan International Cooperation Agency (JICA), the official agency responsible for implementing the technical cooperation programs of the Government of Japan, despatched a fact-finding mission, headed by Mr. T. Nakano, to Thailand in December 1979 to make a preliminary survey and to formulate the scope of works for the Study.

The Study consists of two phases: Phase I (Master Plan) and Phase II (Feasibility Study on Priority Projects). For the Phase I Study, JICA organized a study team, headed by Mr. M. Tohi and composed of experts of Nippon Koei Co., Ltd. and Katahira and Engineers Inc., and commenced the Study in June 1980.

The major objectives of the Phase I Study are summarized as follows:

- To identify needs of the road development in the Northern Region from the viewpoint of regional development, and

- To establish a priority order of the road routes identified and to select priority routes to be recommended for further feasibility studies.

The roads subject to the Study include national highways, provincial roads and major rural roads. It is of urgent requirement to identify major rural road links which will form an important feeder road network in relation with the ongoing Route 11 and Route 1142.

The Department of Highways completed recently the Studies of National and Provincial Road Network in Thailand (SRNT). In the SRNT, screening study has been performed for all improvement projects of existing roads and currently proposed projects, and their priority order has been established. Referring to the results of the SRNT together with its parallel study, DOH has drafted up a new Highway Sector Plan (1982 - 1986). In the draft Plan, a lump sum provision is reserved for about 3,300 km of not-identified routes. Such being the case, an immediate objective of the Study is to provide an indicative list of priority projects of about 300 km in the Northern Region to fulfil a part of the said lump sum provision.

1-2 STUDY SCOPE AND FRAME

The Phase I Study consists of three major parts:

- Analysis of regional characteristics, including assessment of area potentials,
- Identification of routes to be proposed, and
- Evaluation of routes for short/medium term program, including recommendation of priority projects for Phase II Study.

In line with the development target derived from the analysis of regional characteristics, priority links to be considered are to be examined.

Identification of routes is worked out theoretically at first, and then they are screened referring to additional information obtained from DOH and field reconnaissance. This screening process may remove from further studies those routes which are committed by international lending agencies as well as DOH's own budget for implementation within the next five-year plan

period, and also those routes which are judged, prima facie, not feasible due to physical constraints. The routes thus screened are grouped, based on the DOH's policy, into short/medium term program and long term program. Priority ranking for short/medium term projects is worked out through a pre-feasibility level evaluation. Finally, a project package is selected, based on the discussions with DOH, for further feasibility study in Phase II. It is expected that priority projects will be selected among the said package for implementation during next five-year plan period.

Throughout the processes of route identification and evaluation, analyses are based on the condition that all roads currently committed be completed within the next five-year plan period, in other words, before the base year of the evaluation of this Study.

The conceptual flow of the Study is illustrated in Figure 1-1, showing crucial events together with analytical activities required.

This report which presents the results of the Phase I Study consists of the following volumes:

Volume 1 : Text
Volume 2 : Appendixes
Volume 3 : Drawings

1-3 ORGANIZATION FOR THE STUDY

The Study has been carried out by a team of experts under the supervision of the Steering Committee, consisting of Japanese government officials, organized by JICA. In carrying out the Study, the Study Team has kept close collaboration with the Counterpart Team organized by DOH. The organization for the Study is illustrated in Figure 1-2.

Figure 1-1 CONCEPTUAL FLOW OF THE STUDY

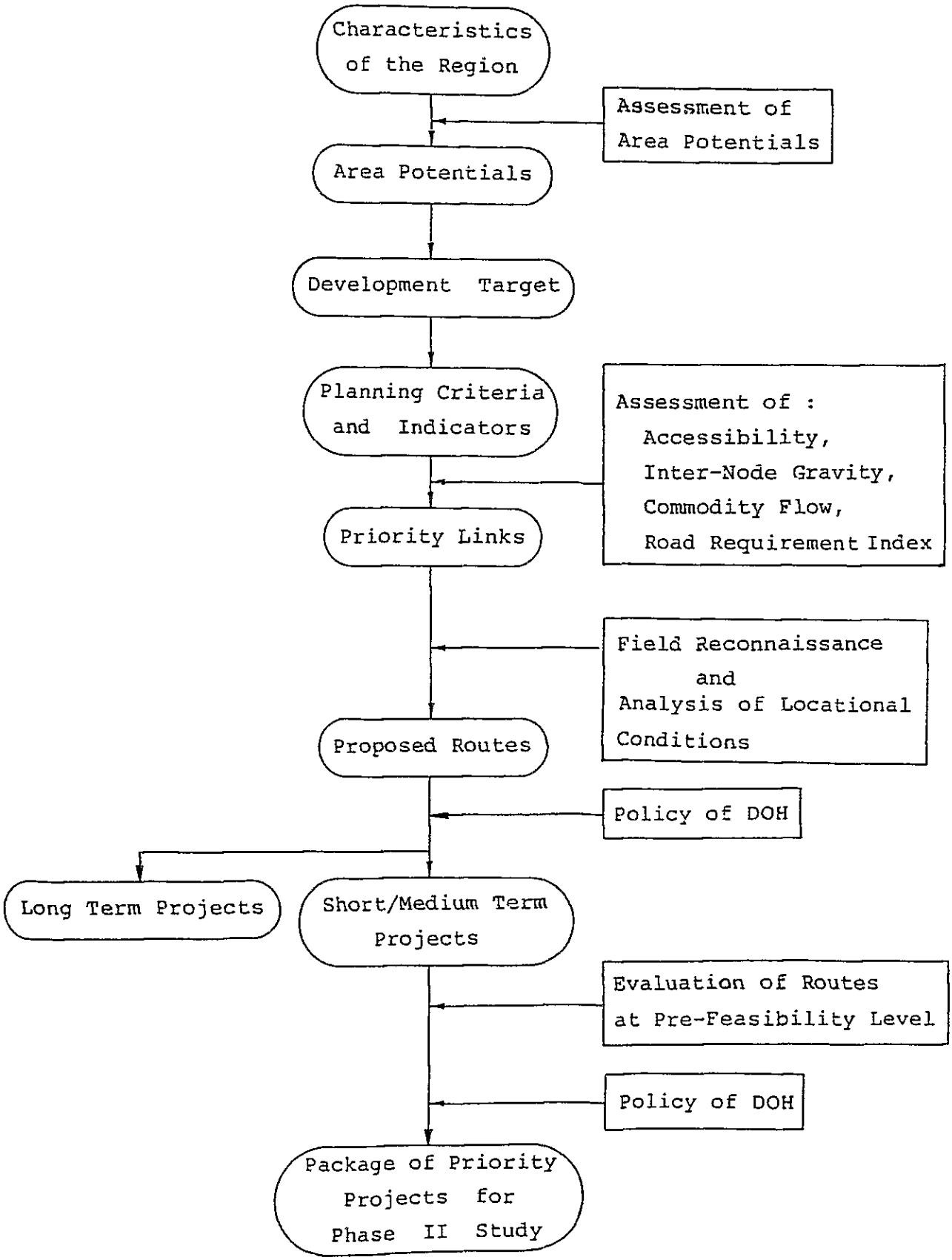
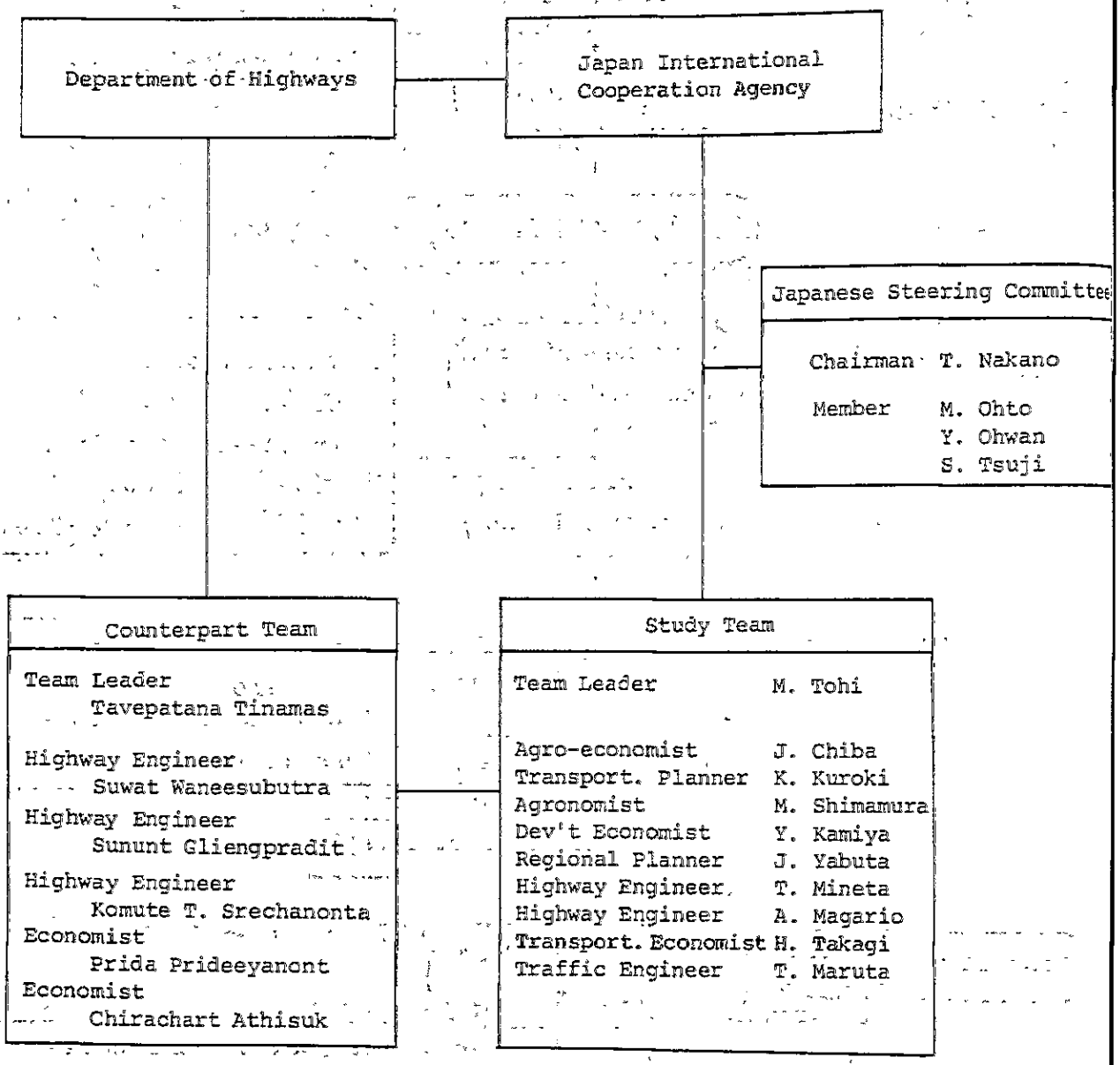


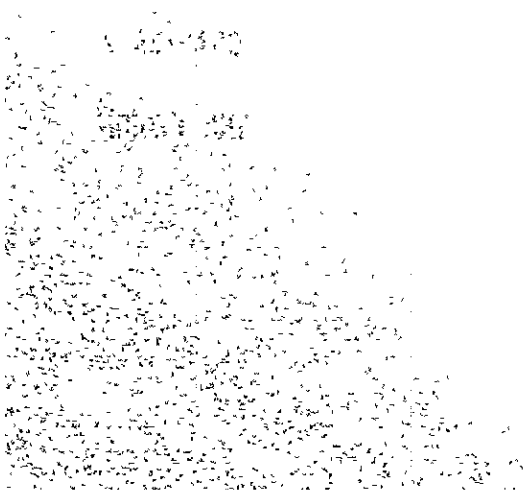
Figure 1-2

Figure 1-2 ORGANIZATION FOR THE STUDY



CHAPTER 2

THE REGION



CHAPTER 2

THE REGION

2-1 LAND AND ECONOMY

Thailand has total land area of 514,000 square km. Its population has grown at the average annual rate of 2.7% during the period of 1970-78 to reach 45,098,000, or 88 persons per square km in density as of 1978. The country is in rainy season during the period from May to October and about 90% of annual rainfall concentrates in this period. The annual rainfall is less in the North and more in the South, but temperature is more or less the same throughout the country except some Northern parts which record relatively low temperature in winter. Mountain ranges occupy the considerable part of the Northern region and extend to the Malay Peninsula along the border with Burma, while a sizable flood plain covers the central part of the country. The country has two major river basins of the Chao Phraya and the Mekong. The Chao Phraya river has its origins in the Northern region and flows into Siam Bay. Sixty percent of the national land is capable of cultivation and 35% is actually cultivated.

Thailand has sustained an aggregate Gross Domestic Product (GDP) growth rate of nearly 8% during the 1970's in spite of the negative impact of the oil price increase. In 1978, the amount of GDP reached 477 billion baht or 10,607 baht per

capita. Its percentage distribution by sector is shown in the following table.

Percent Distribution of GDP by Sector

Sector	1970	1978
Agriculture	28	28
Mining	2	2
Manufacturing	16	18
Trade	19	20
Construction & Services	35	32
GDP	100	100

Source: National Economic and Social Development Boards (NESDB)

Agriculture, which absorbs 76% of the total employment, accounts for 28% of the total GDP following after the construction and services. Unlike other developing countries, relative contribution of agriculture to GDP has not declined. So far, rapid farm land expansion, though it became dull in the latter half of 1970's, has been a main factor responsible for sustained increase in agricultural production. It is manufacturing sector that attained the largest relative increase in the sectoral contribution to GDP. This trend will continue in future.

Population and economic activities are extremely concentrated in the primary city, Bangkok. Degree of the primacy is the highest among the developing countries. Out of the total national population, 17% is "urban", and 62% of urban population live in Bangkok. Bangkok accounts for 29% of GDP, 38% of non-agricultural GDP and 79% of the GDP originated from the sectors of banking, insurance and real estate.

Regarding administration structure, the country comprises 72 Changwat. Each Changwat is divided into more or less ten

Amphoe and each Amphoe is sub-divided into several Tambon which is a group of Muban or villages. Urbanized parts of Changwat are called municipal areas. Another area unit which is used quite often is "region" though it is not official administrative unit. The country is divided into Northern, Northeastern, Central and Southern regions.

The Northern Region occupies 170,000 square km or 33% of the national land. It extends over about 600 km to the North-South direction and about 400 km to the East-West direction. It is an almost rectangular land-locked area surrounded by Burma to the Northwest, Laos and the Northeastern Region to the East, and the Central Region to the South. Its southern end is still 170 km away from the nearest coastal line at which, Bangkok situates. Northern half of the Northern Region or so-called Upper North is a mountainous area while its Southern half or so-called Lower North is covered with flood plain which extends from the Central Region.

Annual average rainfall in the Northern Region is about 1,200 mm, which is sufficiently enough to have verdant forest and single cropping of rice. It varies within the Region ranging from 950 mm in Tak to 1750 mm in Chiang Rai.

The Northern Region is the largest in total land but second in capable and third in cultivated land as observed in the following table. Due to its topography, the capable land area is as low as only 42% of the total area in the Northern Region compared with high share of 76% in the Northeastern Region. On the other hand, the Northern Region accounts for 48% of the national reserved forest, while regional land area is one-third of total land.

Regional Land Use

	Area (1,000 sq.km)			Percent Distribution		
	Total	Capable Land	Cultivated Land	Total	Capable Land	Cultivated Land
Whole Country	514	308	182	100	60	35
Northern Region	170	72	39	100	42	23
Northeastern Region	169	129	74	100	76	44
Central Region	104	63	48	100	61	46
Southern Region	71	44	21	100	62	30

Source: 1) Department of Land Development (DLD), Land Capability Area, 1980

2) DLD, Statistics on Land Utilization by Changwat, 1974-76

Relative position of the Northern Region in the national economy is demonstrated in the following table. Whereas the Northern Region shares 21% of total national population, it shares only 14% of GDP due to the region's low aggregate productivity. Looking at industrial-mix, the Northern Region is predominantly agricultural compared with the rest of the country even excluding Bangkok. On the contrary, contribution of manufacturing sector to GDP is much smaller in the Northern Region than other parts of the country.

The share of the Northern Region in agricultural production, crop production in particular, shows some decline during the period of 1970-78, presumably because topographic conditions of the region results in relatively slow expansion of agricultural lands. Being predominantly agricultural, relative decline in agricultural production together with further concentration of non-agricultural activities in Bangkok and its surroundings leads the Northern Region to relatively low share in total GDP.

Relative Position of Northern Region in National Economy

(%)

	Share of Northern Region		Sectoral Distribution: 1978		
	1970	1978	Northern Region	Thai-land	Thailand excld. Bangkok
Gross Regional Product	15	14	100	100	100
Agriculture	24	23	45	27	37
Crops	28	25	36	20	27
Livestock	21	21	5	3	4
Fisheries	3	3	1	3	4
Forestry	30	34	3	1	2
Mining	18	10	2	2	3
Manufacturing	8	7	9	19	17
Trade	13	13	18	20	19
Construction & Services	12	12	26	32	24
Construction	15	12	5	6	4
Electricity & Water Supply	38	42	3	1	1
Transportation & Communication	10	10	4	6	5
Banking, Insurance & Real Estate	4	6	2	5	1
Ownership of Dwellings	9	10	1	1	2
Public Administration & Defense	13	14	4	4	4
Services	11	12	7	9	6
Population	22	21	-	-	-

Source: NESDB

Population of the Northern Region is 9,544,000 or 21% of the national total in 1978 (See the following table). Annual rate of population increase of the Region is 2.4%, which is lower than national average. The Northern Region is, therefore, an out-migrated area. One reason for this is a limited capacity

of the Region to absorb population due to its topography. In fact, the Northern Region ranks second after the Southern Region in terms of population per cultivated area, although it is the lowest in population density among regions.

Regional Population (1978)

	Population (1000 persons)	Percent Distribution	Annual Rate of Increase 1970-78
Whole Country	45,098	100	2.7
Northern Region	9,544	21	2.4
Northeastern Region	15,941	35	2.9
Central Region excld. Bangkok	9,319	21	2.0
Bangkok	4,736	11	4.8
Southern Region	5,558	12	2.6

Source: NESDB

Regional Population Density (1978)

(persons/km^2)

	Population Per:	
	Total Area	Cultivated Area
Whole Country excld. Bangkok	79	222
Northern Region	56	245
Northeastern Region	94	215
Central Region excld. Bangkok	91	201
Southern Region	78	265

Source: NESDB

Another reason for out-migration is low income level. Income disparity among regions is quite large in Thailand and the Northern Region ranks the second lowest with the per capita income of 6,445 baht or 65 percent of the national average in 1978. In general, the income disparity was reduced during

the period of 1970-78, especially due to relative decline of income level of Bangkok (See the following table). But, relative increase of per capita income was remarkable only in the Central and Southern Regions keeping the Northern Region and the Northeastern Region declining its relative position in income level.

Regional Income Disparity (1970-78)

	Per Capita Income		Index		Index	
	1970	1978	1970	1978	1970	1978
Whole Country	3,741	9,850	100	100	128	·125
Whole Country excld. Bangkok	2,917	7,863	78	80	100	100
Northern Region	2,590	6,445	69	65	89	82
Northeastern Region	1,685	3,962	45	40	58	50
Central Region excld. Bangkok	4,734	14,547	127	148	162	185
Bangkok	12,145	26,781	325	272	416	341
Southern Region	3,743	10,277	100	104	128	131

Level of urbanization is still very low in the Northern Region as elsewhere except Bangkok. Out of 120 municipal areas of the country, the Northern Region has 24 municipal areas with urban population of 630,000 in total (See the following table). It is at most 7% of the total regional population. Municipalities with more than 50,000 populations are only Chiang Mai, Nakhon Sawan and Phitsanulok.

Regional Urban Population (1977)

	Urban Population	Percent Distribution of Urban Population	Ratio of Urban Population
Whole Country	7,591,620	100	17
Bangkok	4,742,774	62	100
Whole Country excld. Bangkok	2,848,846	38	7
Northern Region	628,590	8	7
Northeastern Region	647,614	9	4
Central Region excld. Bangkok	946,703	12	10
Southern Region	625,939	8	11

Source: NESDB

As administrative units, the Northern Region has 17 Changwat, 153 Amphoe, 1,214 Tambon, and 10,431 Muban. The location and population of them, up to Tambon level, is shown in Appendix 2-1 and Drawing 1.

2-2 AGRICULTURE

Similarly with other developing countries, agriculture is most important in Thai economy, especially on account of its contribution to self-sufficiency in food and employment absorption. Thailand is 100% self-sufficient in food, and 65% of its population are absorbed in the agricultural sector. Besides, special attention should be paid to the fact that Thailand is one of the few food-exporting developing countries. Agricultural exports account for 52% of the total exports in 1977/78.

Major crops produced in Thailand include rice, maize, cassava, beans and rubber. Five these crops in total account for 63% of total value added of agricultural products in 1976[1/], 90% of total area planted in 1977/78[2/] and 83% of the export amount of agricultural crops in 1978[3/]. The following table shows long-term change in area planted, yield and production of these crops. Larger increase in production has been attained by those crops for which area planted expanded rapidly. The rapid expansion of uplands took place mainly in response to favorable world market for export crops. It will stop in ten years or so, however, because present capable land of 308,000 square kms as against cultivated land of 182,000 square kms is estimated to be used up in 12 years if current farm land expansion at 4.4% per year is assumed to continue. An attention will be paid inevitably to making full use of already cultivated lands with intensified farm inputs and improved rural infrastructures.

1/ NESDB, National Income of Thailand, 1976

2/ Agricultural Statistics of Thailand, 1977/78

3/ Bank of Thailand

Long-term Change in Crop Production of Thailand

	Crop	Three-Year Average: 1976/77 - 1978/79	Annual Rate of Change: 1967/68 - 1969/70 to 1976/77 - 1978/79
Area Planted (1000 ha)	Rice	8,679	1.9
	Maize	1,292	5.7
	Cassava	890	18.3
	Mungbeans	360	7.2
	Soybeans	139	9.7
	Groundnuts	110	0
	Rubber	1,484	2.0
Yield (ton/ha)	Rice	1.58	0.2
	Maize	1.84	-0.4
	Cassava	14.1	-0.9
	Mungbeans	0.55	-4.6
	Soybeans	0.93	0.4
	Groundnuts	1.17	-0.7
	Rubber	0.29	2.8
Production (1000 ton)	Rice	13,738	2.1
	Maize	2,381	5.3
	Cassava	12,519	17.2
	Mungbeans	197	2.2
	Soybeans	129	10.2
	Groundnuts	129	-0.6
	Rubber	430	4.5

Source: Office of Agricultural Economics, Ministry of Agriculture and Cooperatives.

Transition of agricultural production in the Northern Region is shown in Appendix 2-2.

In terms of value of shipments estimated on the basis of production tonnage and farmgate prices in 1979, rice is the number one crop produced in the Northern Region followed by maize, cassave, mungbeans, sugarcane, tobacco, soybeans, groundnuts, cotton and sorghum. The following table shows performance of the Northern Region in the production of these crops in Thailand. Rice ranks first in area planted also followed by maize, mungbeans, etc. The Northern Region is no exception of the general trend at the national level that farm land expansion contributed more than

Performance of Northern Region in Production of Selected Crops

Crops	Average of 1976/77 - 1978/79			Annual Rate of Change (%) 1967/68-1969/70 to 1976/77-1978/79		Share of Northern Region in National Total Production (%)		Index of Yield of Northern Region (National Average Yield = 100)	
	Area Planted (1,000 ha)	Production (1,000 ton)	Yield (ton/ha)	Area Planted	Production	1967/68 -1969/70	1976/77 -1978/79	1967/68 -1969/70	1976/77 -1978/79
Rice	1,858	4,098	2.21	2.1	3.1	27	30	128	139
Maize	643	1,254	1.95	6.6	7.6	43	53	92	106
Cassava	22	351	16.0	18.7	21.0	2	3	82	113
Mungbeans	278	155	0.56	7.4	2.6	75	78	100	102
Sugarcane	69	2,677	38.8	11.6	15.8	12	12	78	92
Tobacco	39	292	7.49	-	-	-	85	-	98
Soybeans	117	104	0.89	8.0	8.7	92	81	94	96
Groundnuts	61	73	1.20	0.7	-0.8	57	57	110	103
Cotton	23	23	1.00	-9.6	-8.0	65	36	116	92
Sorghum	87	110	1.26	15.3	11.2	64	85	135	77

Source: Office of Agricultural Economics, Ministry of Agriculture and Cooperative.

Department of Excise, Ministry of Finance, re. Tobacco.

yield increase to production increase. Generally, the yield increase in the Northern Region is faster than national average increase. Especially, yield of paddy reaches to the level almost 40% higher than national level. With exception of soybeans and sorghum, relative increase of yield in the Northern Region results in increase of the region's share in national total production. Generally speaking, the Northern Region can be said to show a good performance compared with the rest of the country especially in yield improvement. By implication, investments for agriculture and related infrastructures might as well be made more in the areas where higher yield is promising.

From the viewpoint of cropping pattern, the Northern Region can be divided into three areas as shown below:

Paddy Area (rice cultivation is predominant);
Nakhon Sawan, Phichit, Phitsanulok, Lampang, Chiang Rai and Phayao

Paddy/Upland Crop Area (rice and upland crop cultivation is mixed almost half and half);
Uttaradit, Phrae, Chiang Mai, Lamphun, Kamphaeng Phet, Tak, Sukhothai and Uthai Thani

Upland Crop Area (upland crop cultivation is predominant);
Nan, Mae Hong Son and Phetchabun

The rice area is in the river basin of the Chao Phraya river and its branches, including the Ping, the Yom and the Nan. In Changwat Phichit, rice cultivation accounts for more than 80% of total cropping area. Paddy areas in Changwat Nakhon Sawan, Phichit and Phitsanulok have been suffering from chronic floods of small rivers but an ongoing irrigation project in Phitsanulok would help stabilize and sharply increase the area's rice production upon its completion.

The paddy/upland crop area is mostly undulated land mixed with small areas of alluvial soils. Sugarcane production concentrates on Changwat Kamphaeng Phet, Uttaradit and Lampang while beans such as mungbeans, soybeans and groundnuts are cultivated widely. Those Changwat situating in the Northern part of the Region introduce the crops which are suitable to the peculiar climatic and soil conditions and expected to bear high value added, e.g., tobacco, garlic and chili. Among others, Changwat Chiang Mai is the most progressive in crop diversification as observed in the share of fruit production to reach as much as 16% of total cropping area. In consequence, total value of agricultural production in the Changwat is by far higher than other Changwat.

The dry crop areas are situated in mountainous part where rice is difficult to cultivate. Situating in the Northern part of the Region, Changwat Nan, too, introduces tobacco, garlic and chili. In Changwat Mae Hong Son, cultivation is limited to narrow river valleys and shifting agriculture is still practiced. Changwat Phetchabun is as progressive as Chiang Mai in crop diversification with maize, beans and cotton. Especially maize cultivation of the Changwat forms a part of the corn belt of the country.

Crop productions at Amphoe level are tabulated in Appendix 2-3 and also illustrated in Drawing 2.

2-3 TRANSPORTATION SYSTEM

Transportation network in Thailand, regardless of airlines, railways, roads or inland waterways, has been developed in such a manner to connect every part of the country with Bangkok. This holds in the Northern Region, too. Highways, railways and air lines connecting, in parallel, Bangkok and Chiang Mai form a backbone of the Region's economy. Along this axis, inland waterways extend to Bangkok through Nakhon Sawan. Most of intra-regional transport network, roads in particular, are connected with the Bangkok - Chiang Mai axis.

An overview of the transport system of the Region is described by mode, and briefing on modal split is also given hereunder. Major transportation network in the Region is shown in Figure 2-1.

2-3-1 Railways

The State Railway of Thailand (SRT), the government-owned enterprise, extends its system radiating from Bangkok to the North, Northeast, East and South. The Northern Line up to Chiang Mai shares 751 km in track-km, 17 percent of the country total, and is laid in 9 Changwat in the Region, i.e., Nakhon Sawan, Phichit, Phitsanulok, Uttaradit, Phrae, Lampang, Lamphun, Chiang Mai and Sukhothai.

Although the railway lines are all meter gauge and mostly single track, they have sufficient capacity to carry present passengers and freights. According to the statistics, the system carried 10 million passengers within the Region and 1.8 million passengers from/to Bangkok in 1977. Freights carried from/to Bangkok were 0.7 million tons in 1975.

Although the system has remained static in length for many years, a new plan has been contemplated to lay a new line connecting the system with Sattahip port which is scheduled

to be improved as commercial port. If this plan is realized, the railway freights from the major stations in the Region will increase in future, especially for exportable crops.

2-3-2 Inland Waterways

Inland waterway transport was once in the primary position of transport modes in the upper Central Region and the Northern Region. In 1976, some 8 million tons of freights were carried in waterway transport. The present navigable waterways in the North is confined to the Chao Phraya river system, mainly in the section of about 370 kilometers from Nakhon Sawan to Uttaradit of the Nan river and the Caho Phraya, downstream of Nakhon Sawan.

Low water level during the dry season coupled with high cost of dredging and conflicting needs of water for irrigation, in particular, are constraints to operations of river navigation.

In the Region, there are 7 major riverside ports; Phichit, Taphan Hin, Bang Mun Nak, Chumsaeng, Nakhon Sawan, Phayuha Khiri and Uthai Thani. According to the survey in 1976 by the Harbour Department, about 0.6 million tons were carried by waterways from the Region to Bangkok. More than 80 percent of them is composed of agricultural commodities, mainly maize and paddy.

Shipping on inland waterways is mostly privately-operated. While the waterways are maintained by the RID, the traffic is regulated by the Harbour Department.

2-3-3 Aviation

The Government-owned Thai Airways operates scheduled services from Bangkok to 20 domestic airports in whole country by fleets of Avro-748's or Boeing-737's. From Bangkok to the North, it operates 24 Avro-748's and 11 Boeing-737's a week.

The domestic airports in the Region are in Phitsanulok, Phrae, Nan, Lampang, Chiang Mai, Chiang Rai and Mae Hong Son. Their frequencies of operation range from 4 to 33 a week. The domestic aviation plays a rather minor role in the total domestic transport system in terms of freight volumes and number of passengers.

2-3-4 Highways

The arterial highway network in the Northern Region is formed by three primary highways and 14 secondary highways. The primary highway Route 1, which extends from Bangkok to Chiang Rai via Nakhon Sawan, Tak, Lampang and Phayao, has vital importance as main highway artery in the Region. The other primary highway, Route 12, runs in East-West direction at Central part of the Region from Phetchabun through Phitsanulok and Sukhothai and connects with Route 1 at Tak. The another Primary Route 21 serves mostly in Eastern part of the Region.

The ongoing Route 11, will also play an important part of transportation in collaboration with Route 1.

The secondary highways interwoven with primary highways share the indispensable role of highway transportation in the Region.

A number of provincial roads including the ongoing Route 1142 and rural roads serve for people in the local areas.

The roads in the Northern Region have been managed by many organizations. These are DOH, Accerelated Rural Development Office (ARD), Public Works Department (PWD), Royal Irrigation Department (RID), Mobile Development Unit (MDU), Cooperative Promotion Department and local municipal bodies. Among them, DOH, ARD and PWD have shared the most part of construction and maintenance of the major roads.

In the Northern Region, the total length of roads owned by those major organizations reached at about 16,000 km. More than 80 percent of it is under the jurisdiction of DOH. The DOH road is about 13,000 km in length, of which 6,500 km are paved and 6,500 km which include the roads handed over from ARD are laterite-surfaced roads. The rest of the total length of roads are mostly unpaved roads, consisting of 2,400 km of ARD and 550 km of PWD road. Some sections of routes in the Region are being upgraded or proposed for upgrading by DOH.

The road length by agency in the Region are shown in Table 2-1 and details of it is shown in Appendix 2-4. and also illustrated in Drawing 3.

Major traffic flows between each Changwat of the Region and Bangkok have been surveyed by the Land Transportation Department. According to the survey results, highway system carried 2.2 million tons in total, 1.4 million tons from the North Region and 0.8 million to the North in 1976. Major commodities flowed from the Region to Bangkok are mainly maize, rice, timber and vegetables, while inflows to the Region are miscellaneous goods and gasoline/oil.

The passenger traffic by long distance buses between Bangkok and the Region counted about 200 vehicles per day in 1976.

2-3-5 Modal Split of Commodity Flows

The modal split in the Region were examined through traffic statistics available by mode. For the estimation of modal split of commodities in the Region, the available data on railways, inland waterways and highways in 1976 were compiled by commodity and by origin/destination.

The study on agricultural commodity flows indicates that the flow volumes of the Region from/to Bangkok were 62 percent by roads, 32 percent by waterways and 6 percent by railways. Similarly, for the case of non-agricultural commodity flows,

64 percent was carried by road transport, 31 percent by rail and 5 percent by water. In consequence, it revealed that highway system plays the most important role in the Region except for Phichit who has poor road networks.

Table 2-2 shows the modal split of agricultural and non-agricultural flow from/to Bangkok.

2-4 ROAD DEVELOPMENT

In the absence of diversified network of railways and airlines, it seems inevitable for the Northern Region to rely more on road transportation as its economy grows. Recent improvement of road condition, surface improvement in particular, must have strengthened further the competitiveness of road transport over other transportation modes.

Prior to an assessment of relative levels of road development in the Northern Region, an attempt has been made to make a cross-national comparison of road density in relation to a socio-economic indicator. A series of regression analyses have revealed that an indicator denoted by geometrical mean of population density and GNP per area, called "socio-economic intensity", can well explain level of road density in the following model:

$$Y = a + b \cdot X$$

where, Y : Road density
X : Socio-economic intensity

Parameters of the model have been determined in two cases; the one for all countries regardless of developed or developing and the other for developing countries. Derived formulae are:

All countries : $Y_i = 117 + 5.98\ X_i$ ($r = 0.955$)
where, i = 1 through 23
(See table 2-3)

Developing countries : $Y_i = 65 + 3.68\ X_i$ ($r = 0.818$)
where, i = 1, 2, 4, 5, 6, 7, 8, 21 and 22 (See table 2-3)

According to the formula derived for all countries, Thailand is positioned to have the road density of 266 m per square kms which is about 2.5 times higher than actual density. Even by

"developing country standard" based on another formula, Thailand is positioned to have the road density of 157 m per square kms which is still 1.5 times higher than actual density.

Next, road density of the Northern Region has been compared with other regions, in relation with various indicators measured in density term with reference to road requirement for various factors. Indicators were set as follows in view of development objectives which road sector is supposed to aim at:

Indicators in view of regional development; capable land, population, number of Changwat and Amphoe, GRP.

Indicators in view of rural/agricultural development; cultivated land, uncultivated capable land, rural population, farm population, number of Tambon and Muban, Agricultural GRP.

Indicators in view of urban/industrial development; urban population, non-farm population, non-agricultural GRP.

On the basis of the regression analysis, the correlationship among road density and these indicators was identified by the following formula, and parameters were estimated by each case:

$$Y_i = a \cdot X_i^b$$

where, Y_i : Road density;

X_i : Indicators (in density term) and

i : Denotes the four regions in Thailand

Ratios of actual road density to the road density requirement derived from the above formula was calculated as in the Table 2-4 for the basis of inter-regional comparison. The ratio less than unity means the relative insufficiency of road den-

sity for its corresponding indicator. Looking at the Table, it is quite obvious that road density in the Northern Region is below the required level by any standard. Especially, the gap between actual and required level is large when the road density is compared with availability of uncultivated capable land, urban population density, non-farm population density, number of Changwat and GRP. Compared with other regions, it can be said, therefore, that the road density in the Northern Region is still inadequate considering its economic contribution, urban activities and future land potential.

2-5 REGIONAL DEVELOPMENT

Recently, increased concerns are given to reducing economic disparities among regions. The Fourth National Economic and Social Development Plan (1977-81, hereinafter referred to as the Fourth Plan) stresses the economic development with its emphasis on less developed regions, including the North, and the decentralization of basic infrastructures and social services.

According to the Fourth Plan, economic concentration on Bangkok and the Central Region has been caused by the dependence of economy of other regions on limited sectors, agriculture in particular. Even in the agricultural sector, other regions are less diversified than the Central Region. The low level of agricultural diversification resulted in instable production, extensive use of farm levels, and underutilization of water and manpower resources. On one hand, this trend accelerated regional out-migration especially in the Northern Region where cultivable lands are limited and, on the other, encroachment of forest areas especially in the Northern and Northeastern Regions. In the absence of viable non-metropolitan cities to absorb surplus rural population, rural-to-urban migration flocked mostly into Bangkok.

In order to attain the agricultural diversification as a main thrust of rural development, it is emphasized that links be strengthened between agricultural production and processing, between remote areas such as highland areas and local market centers and between export crop production and port of export. Stimulation of agricultural diversification is thus expected to contribute to growth of agro-based industries, increase in urban employment opportunities and, in turn, reinforcement of urban service functions. In the Northern Region, cities of Chiang Mai and Phitsanulok are designated as regional growth centers.

It is envisaged that this process of development needs to be supported by decentralization of major infrastructural facilities such as roads, irrigation and power facilities. A stress is laid on improving system of branch lines such as feeder roads, tertiary irrigation canals and rural power distribution lines not only for helping exploit potential resources but for attaining full utilization of existing trunk facilities such as national highways. In fact, it is sometimes pointed out that well developed trunk facilities are used to the extent far below their optimum capacity because they do not really penetrate into the areas or population to be served due to lack of adequate branch facilities.

Figure 2-1

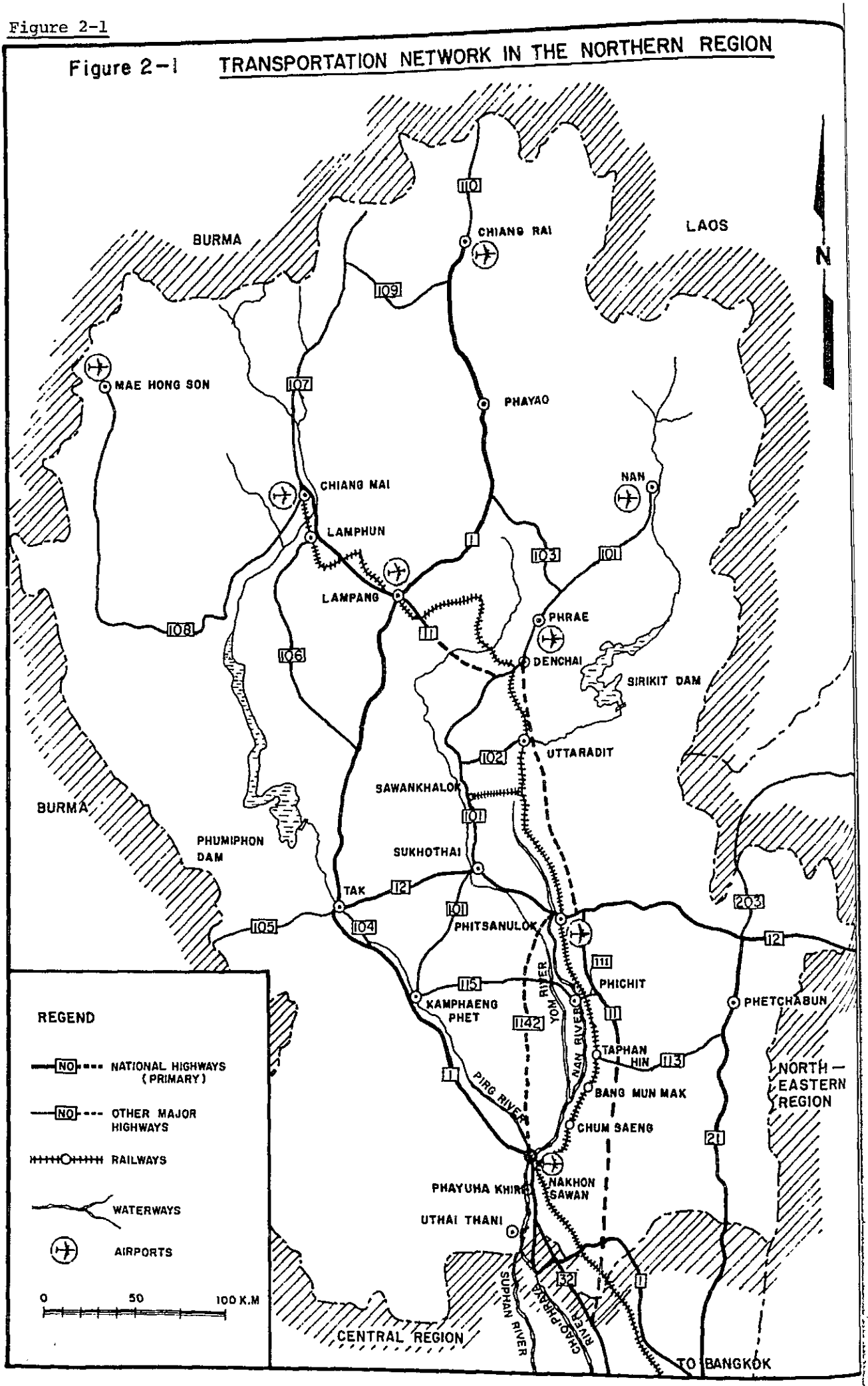


Figure 2-1 TRANSPORTATION NETWORK IN THE NORTHERN REGION
BURMA
LAOS
CHIANG RAI
MAE HONG SON
PHAYAO
CHIANG MAI
NAN
LAMPHUN
LAMPANG
PHRAE
DENCHAI
SIRIKIT DAM
UTTARADIT
SAWANKHALOK
SUKHOTHAI
PHUMIPHON DAM
TAK
PHITSANULOK
PHICHIT
KAMPHAENG PHET
PHETCHABUN
TAPHAN HIN
BANG MUN MAK
CHUM SAENG
NAKHON SAWAN
PHAYUHA KHIRI
UTHAI THANI
NORTH-EASTERN REGION
CENTRAL REGION
TO BANGKOK
YOM RIVER
NAN RIVER
PING RIVER
SUPHAN RIVER
CHAO PHRAYA RIVER
REGEND
NATIONAL HIGHWAYS (PRIMARY)
OTHER MAJOR HIGHWAYS
RAILWAYS
WATERWAYS
AIRPORTS
0 50 100 K.M

Table 2-1 LENGTH OF MAJOR ROADS IN THE REGION

(Km)

Changwat	DOH Road		ARD Road		PWD Road		Total	
	Paved (Unpaved)	Total	Paved (Unpaved)	Total	Paved (Unpaved)	Total	Paved (Unpaved)	Total
Nakhon Sawan	415.5 (578.6)	994.1	- (27.0)	27.0	- (63.7)	63.7	415.5 (669.3)	1084.8
Phichit	301.7 (109.5)	411.2	- (6.1)	6.1	- (67.7)	67.7	301.7 (183.3)	485.0
Phitsanulok	391.3 (273.2)	644.5	- (128.8)	128.8	- -	-	391.3 (402.0)	793.3
Uttaradit	319.2 (676.9)	996.1	- (312.0)	312.0	- -	-	319.2 (988.9)	1308.1
Phrae	310.9 (357.1)	668.0	- (78.3)	78.3	- -	-	310.9 (435.4)	746.3
Lampang	524.1 (290.3)	814.4	6.0 (318.7)	324.7	- -	-	530.1 (609.0)	1139.1
Nan	518.5 (345.2)	863.7	7.6 (294.1)	301.7	- -	-	526.1 (639.4)	1165.5
Phayao	335.1 (244.4)	579.5	- (65.6)	65.6	- -	-	335.1 (310.0)	645.1
Chiang Rai	576.1 (545.3)	1121.4	- (185.6)	185.6	- -	-	576.1 (730.9)	1307.0
Chiang Mai	678.9 (754.3)	1433.2	- (241.6)	241.6	- -	-	678.9 (995.9)	1674.8
Mae Hong Son	202.8 (255.3)	458.1	- (37.7)	37.7	- -	-	202.8 (293.0)	495.8
Lamphun	305.6 (228.5)	534.1	- (25.0)	25.0	- (13.5)	13.5	305.6 (267.0)	572.6
Tak	445.1 (451.5)	896.6	- (122.9)	122.9	- -	-	445.1 (574.4)	1019.5
Sukhothai	308.1 (210.7)	518.8	- (20.0)	20.0	- (101.4)	101.4	308.1 (332.1)	640.2
Kamphaeng Phet	313.5 (414.8)	728.3	- (53.1)	53.1	- (176.0)	176.0	313.5 (643.9)	957.4
Uthai Thani	54.4 (313.9)	368.3	- (26.1)	26.1	- (127.1)	127.1	54.4 (467.1)	521.5
Phetchabun	472.6 (499.4)	972.0	- (434.4)	434.4	- -	-	472.6 (934.8)	1406.4
Total	6473.4 (6548.9)	13022.3	13.6 (2377.0)	2390.6	- (549.4)	549.4	6487.0 (9475.3)	15962.3

Table 2-2

Table 2-2 MODAL SPLIT OF COMMODITY FLOW FROM/TO BANGKOK

(%)

Changwat	Agricultural Products			Other Commodities		
	Railway	Waterway	Highway	Railway	Waterway	Highway
Nakhon Sawan	0.0	40.8	59.2	14.4	13.9	71.7
Phichit	17.1	78.0	4.9	48.4	22.1	29.5
Phitsanulok	43.1	-	56.9	45.3	-	54.7
Uttaradit	29.2	-	70.8	49.6	-	50.4
Phrae	27.1	-	72.9	55.6	-	44.4
Lampang	1.9	-	98.1	58.8	-	41.2
Chiang Mai	1.1	-	98.9	43.3	-	56.7
Lamphun	0.0	-	100.0	81.2	-	18.8
Sukhothai	1.1	-	98.9	0.2	-	99.8
Uthai Thani	-	23.6	76.4	-	12.8	87.2
Others	-	-	100.0	-	-	100.0
Total	6.1	32.2	61.7	31.2	4.7	64.1

Table 2-3 SELECTED INDICATIONS FOR GROSS-NATIONAL COMPARISON OF ROAD DENSITY

No.	Country	Area (1000 km^2) (A)	Population (1000 persons) (P)	GNP (billion yen) (G)	Road Length (1000 km) (L)
1	India	3,288	586,266	19,509	895.0
2	Indonesia	1,492	127,586	4,776	35.6
3	Japan	372	109,671	132,725	699.1
4	Korea	98	33,459	4,242	44.2
5	Malaysia	330	11,650	2,211	19.4
6	Pakistan	804	68,214	2,589	33.2
7	Philippines	300	41,457	4,248	104.2
8	Thailand	514	41,023	3,975	54.9 1/
9	Denmark	43	5,045	9,840	65.7
10	France	547	52,507	86,382	794.0
11	W. Germany	249	62,041	124,071	463.0
12	U.K.	244	55,968	56,928	366.7
13	Italy	301	55,361	45,006	286.5
14	Netherlands	41	13,541	22,257	104.1
15	Norway	324	3,985	7,416	76.1
16	Sweden	450	8,161	18,303	97.4
17	Belgium	31	9,772	17,283	93.1
18	Hungary	93	10,478	11,817	99.8
19	Spain	505	35,225	19,002	315.0
20	Switzerland	41	6,443	15,804	61.6
21	Yugoslavia	256	21,153	7,140	78.7
22	Mexico	1,973	58,118	19,509	426.1
23	U.S.A.	9,363	211,909	419,400	6,140.9

No.	Country	Population Density (person/km^2) (P/A)	GNP Per Area (1000 yen/km^2) (G/A)	Road Density (m/km^2) (L/A)	Socio-economic intensity $\sqrt{(P/A)(G/A)}$
1	India	178	5,933	272	32.50
2	Indonesia	86	3,201	24	16.59
3	Japan	295	356,788	1,871	324.43
4	Korea	341	43,286	451	121.49
5	Malaysia	35	6,700	59	15.31
6	Pakistan	85	3,220	41	16.54
7	Philippines	138	14,160	347	44.20
8	Thailand	80	7,733	108	24.87
9	Denmark	117	228,837	1,528	163.63
10	France	96	157,920	1,452	123.13
11	W. Germany	249	498,277	1,859	352.24
12	U.K.	229	233,311	1,503	231.14
13	Italy	184	149,522	952	165.87
14	Netherlands	330	542,854	2,539	423.25
15	Norway	12	22,889	235	16.57
16	Sweden	18	40,673	216	27.06
17	Belgium	315	557,516	3,003	419.06
18	Hungary	113	127,065	1,073	119.82
19	Spain	70	37,628	624	51.32
20	Switzerland	157	385,463	1,502	246.00
21	Yugoslavia	83	27,891	307	48.11
22	Mexico	29	9,888	216	16.93
23	U.S.A.	23	44,793	656	32.10

Note: 1/ Including all roads under DOH, ARD and PWD

Source: International Road Federation 1977

Table 2-4

Table 2-4 INTER-REGIONAL COMPARISON OF ROAD DENSITY: RATIO OF ACTUAL TO REQUIRED LEVEL

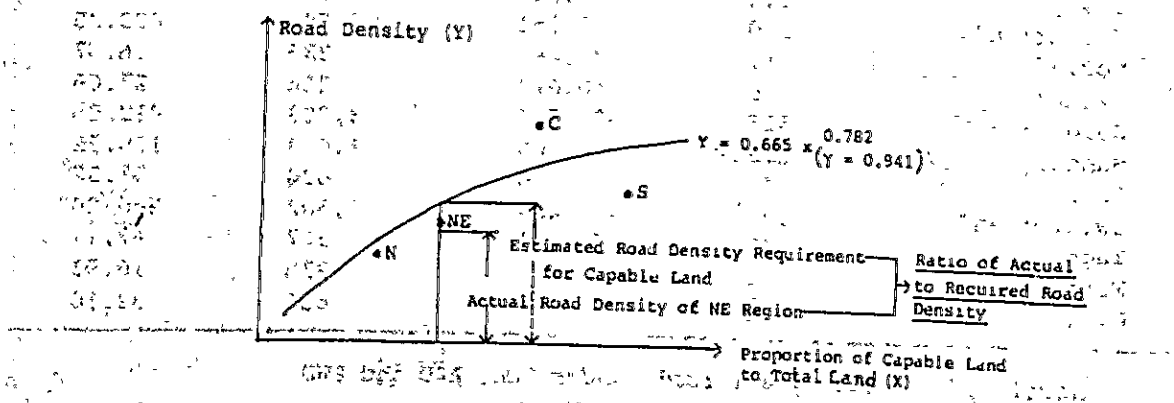
	Ratio of Actual to Required Road Density				Coefficient of Model Formula		
	North	North-east	South	Central	Constant (a)	Multip. (b)	Correl. (r)
Percentage, in Total Area, of:							
Capable Land	0.984	0.858	1.081	0.996	0.665	0.782	0.941
Cultivated Land	0.889	0.992	1.207	0.940	1.532	0.331	0.627
Uncultivated Capable Land	0.811	0.999	1.127	1.140	1.739	0.220	0.505
Density of:							
Population	0.924	0.994	1.158	1.291	0.945	0.579	0.797
Rural Population	0.909	0.974	1.177	0.933	1.065	0.527	0.770
Farm Population	0.667	1.046	1.196	0.919	1.525	0.297	0.547
Urban Population	0.851	1.168	1.068	0.933	1.894	0.189	0.578
Non-farm Population	0.780	0.884	0.955	1.050	1.662	0.314	0.682
Number, in Unit Area, of:							
Changwat	0.839	1.168	1.076	0.944	1.838	0.175	0.526
Amphoe	0.929	1.134	1.032	0.919	1.163	0.417	0.818
Tambon	0.910	1.134	1.068	0.902	1.017	0.337	0.754
Muban	0.942	0.999	1.153	0.912	0.476	0.394	0.795
GRP, per Unit Area, from:							
All Sectors	0.839	1.149	1.117	0.933	1.673	0.134	0.486
Agricultural Sectors	0.849	1.147	1.103	0.921	1.535	0.217	0.541
Non-agricultural Sectors	0.837	1.152	1.122	0.940	1.770	0.107	0.467

Note: Model formula is: $Y_i = aX_i^b$, i = 1, 2, 3 and 4 respectively for North, Northeast, South and Central

Y is road density or road length per area (km/1000 km^2)

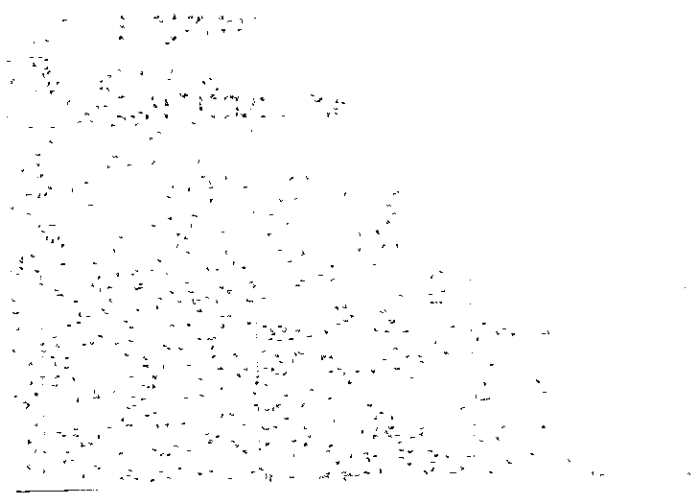
X is indicator shown in the left column of the table

Example of the case for capable land is illustrated below:



CHAPTER 3

AREA POTENTIALS



CHAPTER 3

AREA POTENTIALS

3-1 CONCEPTUAL FRAME

3-1-1 Approach

For any project planning, it is necessary to start with identification of needs. The needs are to be identified from the viewpoints of both the sector to which a project in question belongs and the area in which the project is going to be located. Since this study aims at preparing a master plan for road development over the whole part of the Northern Region, the assessment of the area characteristics is one of the most crucial issues to be initiated prior to the identification of needs.

The foregoing analysis has revealed the relative position of the Northern Region in the national space, economy, transportations and development policies. It has also suggested the salient points to be taken into account in the Northern Region such as productivity and diversity of crop production, expansion of farm lands versus topographic or environmental constraints, scale and distribution of urban centers, and population absorptive capacity. In view of these points, a systematic set of criteria and quantitative indicators needs to be formulated in order for areal analysis not just to be

descriptive but to be operational for project identification. It is in this connection that area potentials are defined, estimated and assessed.

By area potentials the Study means present levels of socio-economic activities and their implications to future prospects of an area. Potentials of an area can be measured in many ways and there is no universal method of estimations. Population can be a simple but convenient aggregate indicator. However, an attempt was made in this Study to look at the areal potentials from various angles. It may respond to varying needs for road development such as ensuring accessibilities for economic activities and populations, making full use of potential resources, land in particular, and strengthening urban functions and also to the salient points to be taken into account in the Northern Region. Hence, the criteria selected for area potential assessment are:

a) Future land potential
b) Performance of major productive sectors
c) Levels of urban activities and services, and
d) Population factor

Area potentials are assessed at regional, Changwat and Amphoe levels.

3-1-2 Indicators and Data

To measure area potentials, indicators need to be determined in view of not only their relevance to criteria but data availability which is, in fact, the most crucial especially for analysis at the Amphoe level. A list of the indicators selected is shown together with data sources in Appendix 3-1.

For the assessment of future land potential, two distinct indicators are chosen. They are area of lands planned to be irrigated and area of unused cultivable lands. Despite their

common feature of indicating future land potential, the two indicators have different policy implications. The area of lands planned to be irrigated is an indicator of the potentials for intensification of agricultural production within already cultivated area and a higher value of the indicator suggests the need for further feeder road inputs in such area. On the contrary, the area of unused cultivable lands is an indicator of the potentials for expansion of farm lands, upland in particular, and a higher value of the indicator may suggest a greater emphasis on the role of road development in guiding appropriate expansion of farm lands.

For assessing the performance of major productive sectors, agricultural indicators are chosen in the first place in view of predominantly agricultural economy of the region. They include value of agricultural and livestock production, area of cultivated lands and number of agricultural households. Fishery is not included due to its negligible contribution to the economy of the Northern Region. Forestry is excluded, too, since forestry production of some part of the Northern Region has been limited by the government control, and this policy is expected to be strengthened in future. Value of livestock production is taken as a separate indicator from that of agricultural production taking into account its high potential given by the government stress on agricultural diversification policy.

Mining production is chosen as another significant indicator because of its considerable contribution to the economy in limited part of the region. Manufacturing, trade and tourism activities are not chosen under this criteria but put aside to be measured in terms of urban activities because the notion of urban activities seems more relevant than that of manufacturing or trade to local situation and it is easier to be quantified by using available statistics.

Regarding the assessment of urban activities/services, their complexity together with lack of directly relevant data results in choosing as many as seven indicators, including urban population, non-agricultural population, amount of electricity consumption, number of postal matters, number of secondary school teachers, number of doctors in hospitals and freight volume handled. Both urban population and non-agricultural population are supposed to represent the magnitude of overall socio-economic activities in urban places. While the indicator of urban population distribution tends to magnify Changwat centers because few urban centers other than Changwat centers are officially defined as "urban" though they are sometimes as large as Changwat centers, assessment by the indicator of non-agricultural population would be in favour of medium or small urban centers. Amount of electricity consumption, freight volume handled and number of postal matters are meant for indicating intensity of urban economic activities, including manufacturing and commerce. Number of secondary school teachers and number of doctors in hospitals are meant for indicating degree of concentration of social services in an urban place.

For the assessment of population factors, three indicators of population size, population increase and population density are chosen. Besides that population indicates the size of demand for public facilities including roads, it represents overall magnitude of socio-economic activities of an area. While population size and population density are supposed to indicate the demand for public facilities and the overall magnitude of socio-economic activities at the present time, population increase is supposed to indicate their future potential.

3-2 METHOD OF ESTIMATION

Given a set of criteria and indicators with relevant data, the measurement of area potentials needs to tackle with two issues of how several data with quite different units and patterns of distribution can be made comparable enough to be aggregated, and what the weighting among criteria/indicators should be in their aggregation.

There are many ways to standardize different data but this study has employed the method of transforming all indicators into the indicator of population or, in other words, expressing all kinds of data in population term, by making mean and standard deviation of different data series uniform with those of population. This method takes its cue from the method of normalization.[1/]

The formula for transformation is:

$$Z_i = \mu_p + \sigma_p \cdot \frac{(X_i - \bar{X})}{S_x}$$

where,

Z_i : Data transformed from X_i

μ_p : Mean of population data

σ_p : Standard deviation of population data

X_i : Original data series for indicator X

$\bar{X}$: Mean of data X_i

S_x : Standard deviation of data X_i

1/ Modification of ordinary normalizations has been found necessary in order to keep operationality of the area potentials from being impaired by the negative values incident to normalization. Theoretical background of the method is briefly described in Appendix 3-2.

As for weighting method, it has been found that a number of studies[1/] have employed similar methods and, in common, equal weight has been assigned among different indicators. With these examples, the aggregate potentials have been estimated by assigning an equal weight to each criteria/indicator. The underlying premise here is that plausibleness of estimated area potentials depends essentially on whether variety of indicators and their combination are sound rather than on how the weighting system is.

Data for respective indicators are shown as such on Appendixes 3-3 and 3-4, and as transformed on Appendixes 3-5 and 3-6. Due to difference in kinds of available/relevant data between Changwat and Amphoe levels, indicators and data have been somewhat simplified for the estimation of area potentials at the Changwat level. A table comparing the indicators and data used at the Amphoe level and those at the Changwat level is shown in Appendix 3-7.

1/ a) Toyo Keizai News, Regional Economic Indicator
b) Asahi News, Economic Indicator
c) National Living Standard Committee, Social Indicator
d) National Economic and Social Development Board, South Thailand Regional Planning Study

Of these, a), b) and c) deal with Japanese experiences.

3-3 ASSESSMENT

3-3-1 Assessment of Regional Level

Looking first at relative position of the Northern Region as a whole, it ranks the third among four regions in terms of aggregated area potentials[1/] (See the table). While the Northern Region is the second highest, next to the Northeastern Region, in future land potential, it is the lowest in levels of urban activities/services. The Central Region indicates the highest potential in performance of major productive sectors and levels of urban activities/services while the Northeastern Region indicates the highest potential in future land potential and population factor. In sum, potential of the Northern Region cannot be said to be high compared with other parts of the country in spite of relatively high potential of land development.

Area Potentials: Inter-regional Comparison

(in thousand)

Region	Aggregated Area Potentials	Future Land Potential	Performance of Major Productive Sectors	Levels of Urban Activities/ Services	Population Factor
North	9,000	12,000	8,400	7,300	9,100
Central	14,100	11,300	15,300	16,300	9,800
Northeast	12,600	13,100	11,200	7,900	15,800
South	4,700	3,900	5,400	8,800	5,700

3-3-2 Assessment of Changwat Level

Area potentials of all Changwat of the country have been worked out in order to verify the consistency of estimated area potentials with regional structure as widely perceived as well as to

1/ Bangkok is excluded from Central Region hereinafter in this chapter.

have a closer look into the relative potential of the Northern Region. Table 3-1 shows the area potentials measured on respective criteria and aggregated area potentials. Table 3-2 shows ranking of Changwat in the area potentials measured on respective criteria and those aggregated.

In terms of future land potential, Kanchanaburi ranks the top followed by Ubon Ratchathani, Phichit, Nakhon Si Thammarat, Nakhon Ratchasima, Surat Thani, Kamphaeng Phet, Narathiwat, Kalasin, Khon Kaen and so forth. Generally, availability of unused cultivable lands appears to be major factor in high future land potential of Changwat in the Northeastern Region while the major factor appears to be the lands expected to be irrigated in case of those in the Northern and Central Regions. In the Northern Region, large-scale irrigation projects are underway in those Changwat highly ranked such as Phichit, Kamphaeng Phet and Phitsanulok. Due attention needs to be paid to the importance of irrigation in land potential of the Northern Region.

In terms of present performance of major productive sectors, Nakhon Ratchasima ranks the top followed by Nakhon Si Thammarat, Kanchanaburi, Phetchabun, Saraburi, Suphan Buri, Udon Thani, Ubon Ratchathani, Nakhon Sawan, Phangnga and so forth. These high ranking Changwat are categorized broadly into: those producing diversified crops, especially export crops such as maize, cassava and sugarcane on top of considerable volume of rice, e.g., Nakhon Ratchasima, Kanchanaburi, Phetchabun, Saraburi, Suphan Buri and Nakhon Sawan; these producing huge amount of rice with very limited production of other crops, e.g., Ubon Ratchathani and Udon Thani of the Northeast, being number one and two of the country in rice planted area; and those specialized in mining industry, e.g., Nakhon Si Thammarat and Phangnga of the South. High ranking Changwat of the Northern Region belong to the first category, namely, rice with export crops. A series of regional and

infrastructural development policies designed to attain agricultural diversification as mentioned in the foregoing chapter could help development of these Changwat effectively.

In terms of levels of urban activities/services, Songkhla ranks the first followed by Chiang Mai, Chon Buri, Nakhon Ratchasima, Ubon Ratchathani, Nakhon Si Thammarat, Udon Thani, Ratchaburi, Nakhon Sawan, Khon Kaen, Phitsanulok and so forth. Those designated as urban growth centers all rank high except for Phuket which ranks the twenty-eighth. Instead, Nakhon Si Thammarat, Ratchaburi and Nakhon Sawan rank high. Although, they are not the growth centers as designated, they play an important role especially in distribution of agricultural and other primary products.

In terms of population factor, Nakhon Ratchasima ranks the first followed by Ubon Ratchathani, Udon Thani, Nakhon Si Thammarat, Khon Kaen, Buri Ram, Roi Et, Si Sa Ket, Surin and Nakhon Sawan. Eight out of ten these Changwat are in the Northeastern Region. Vast cultivable lands of the region is supposed to have enabled it to absorb population. In fact, all these Changwat except Khon Kaen are still experiencing faster population growth than the national average.[1/] Population factor comprising of size, increase and density of population is taken to indicate potential of a area but, at the same time, it can be taken to indicate demand pressure on infrastructure and services especially in less developed area such as Buri Ram, Roi Et, Si Sa Ket and Surin of the Northeastern Region. In the context of the Northern Region, population factor indicates exactly the area potentials as developed Changwat rank high, e.g., Nakhon Sawan, Phetchabun, Chiang Mai, Chiang Rai, Phitsanulok and so on.

After all, Nakhon Ratchasima ranks the first in aggregated area potentials, followed by Ubon Ratchathani, Nakhon Si

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1/ National average is computed excluding the population of Bangkok.

Thammarat, Kanchanaburi, Chiang Mai, Udon Thani, Khon Kaen, Songkhla, Nakhon Sawan and Chon Buri. Out of seventeen Changwat of the Northern Region, potentials of seven Changwat are higher than national average in aggregated term and they include Chiang Mai, Nakhon Sawan, Phitsanulok, Phichit, Phetchabun, Kamphaeng Phet and Chiang Rai.

3-3-3 Assessment of Amphoe Level

It is inferred that the results reflect adequately regional structure which is widely perceived, with the reservation that some national level strategies for regional development are not taken into account in the area potential. In order to have a more specific look into the regional characteristics, a focus is given to the area potentials at the Amphoe level.

Then, patterns of area potentials within the Northern Region were examined. Table 3-3 shows the area potentials measured on respective criteria and aggregated area potentials. The Table 3-4 lists up all Amphoe in order of aggregated area potentials.

According to Table 3-4, among top twenty Amphoe, twelve are Changwat centers, including Chiang Mai, Phitsanulok, Kamphaeng Phet, Nakhon Sawan and so forth. Other eight Amphoe can be categorized into those with high land potential including Khlong Khlung and Khanu Woralaksaburi in Changwat Kamphaeng Phet, Taphan Hin in Changwat Phichit, Chon Daen in Changwat Phetchabun and Wang Thong in Changwat Phitsanulok; and those with high potential in terms of population factor and located adjacent to Changwat center, including Lat Yao next to Muang Nakhon Sawan, Phan next to Muang Chiang Rai and Lom Sak next to Muang Phetchabun.

Bottom twenty Amphoe are located mostly along or near the border. The lowest eight Amphoe among the bottom twenty indicate extremely poor performance of major productive sectors. They include Ban Khok and Fak Tha in Changwat Uttaradit, Na Muen, Mae Charim, Ban Luang and Thung Chang in Changwat Nan, Nam Nao in Changwat Phetchabun and Thung Hua Chang in Changwat Lamphun. The rest of the bottom performance of major productive sectors, including Khum Yuam and Mae La Noi in Changwat Mae Hong Son, Na Noi and Chiang Klang in Changwat Nan, Chiang Mun in Changwat Phayao, Den Chai in Changwat Phrae and Mae Phrik in Changwat Lampang; and those indicating limited future land potential or population absorption, including Pai in Changwat Mae Hong Son, Samoeng in Changwat Chiang Mai, Phop Phra in Changwat Tak, Tha Pla in Changwat Uttaradit and Pa Daet in Changwat Chiang Rai.

In sum, future potential of lands to be either irrigated or cultivated is observed to have very much to do with aggregated potentials of Amphoe. Second, location of Amphoe particularly in terms of closeness to Changwat center is another factor of the aggregated area potentials. Third, extremely poor performance of major productive sector, agriculture in particular, is an absolute factor of lower area potential in spite of relatively high potentials in terms of land or population.

3-3-4 Geographic Characteristics of Area Potentials

Looking at geographical pattern of area potentials (See Figure 3-1) three agglomerations are clearly observed; the largest in the Southeastern part of the region covering whole or most part of Changwat Nakhon Sawan, Phichit, Phitsanulok, Sukhothai, Kamphaeng Phet, Uthai Thani and Phetchabun and the western half of Changwat Uttaradit, the second largest in the northernmost of the Region covering the eastern part of Changwat Phayao, the northern and central parts of Changwat Chiang Rai and the northern tip of Changwat Chiang Mai, and the third largest

but the highest in terms of intensity covering the central part of Changwat Lamphun, the southeastern part of Changwat Chiang Mai, and the northern part of Changwat Lampang.

Outside these agglomeration, some linear type agglomerations can be observed such as Kamphaeng Phet - Tak - Lampang belt, Lamphun - Phrae-Nan belt and Chiang Rai-Chiang Mai belt.

Interpreting geographical pattern of area potentials in this manner, three alternative strategies would emerge for regional and infrastructural development. The first is to concentrate investments in the three agglomerations so as to fully mobilize their potentials, especially land potential for export crops and agricultural diversification in the Southeast agglomeration, water resource potential for higher productivity in agriculture in the Chiang Rai agglomeration and urban growth potential with related economic potentials in the Chiang Mai agglomeration. The second is to expand investment especially along the linear type agglomerations so that three agglomerations are merged in the long run thereby enabling developing the whole region as a single economic counter-unit to Bangkok. The third is to give special emphasis on the areas outside the agglomerations in order to ensure basic standard of living for the people whatever the areal potentials are and to integrate isolated and thus low potential areas into national/regional economy.

It is not intended here to conclude what the best alternative is. Possible choice depends on whether long or short term viewpoint, whether national or regional viewpoint and whether economic efficiency to be given priority or social stability. In case of road development, however, these discussions can be boiled down to how to harmonize the view to build up the overall network of roads for a balanced development of the region and another view to intensify road network for a maximum development of high potential areas.

The quantified area potentials of Amphoe are applied later in the study of route identification. In one way, they are employed as one of the elements in the estimation of inter-node gravity to assess the relative importance of interactions between specific zones/area. In another, area potentials are incorporated again in the calculation of road requirement index for the assessment of priority areas for providing feeder roads.

Figure 3-1 AGGREGATED AREA POTENTIALS

AA HOE CODE NO AND NAME

0101 * NAKHON SAWAN	1001 M. CHIANG MAI
0102 * YAS	1002 MAE AI
0103 PHOT PHISAI	1003 FANG
0104 LIEO	1004 CHIANG DAO
0105 *SAENG	1005 MAE TAENG
0106 K PHRA	1006 PHRAO
0107 YUNA KHIRI	1007 SAMOENG
0108 HLI	1008 MAE RIM
0109 I TAKO	1009 SAN SAI
0110 HSALI	1010 DOI SAKET
0111 G BUA	1011 SAN KAMPHAENG
0112 K FA	1012 SARAPHI
0201 PHICHIT	1013 HANG DONG
0202 I NGAM	1014 SAN PA TONG
0203 HAN HIN	1015 CHOM THONG
0204 G MUN NAK	1016 MAE CHAEM
0205 D TAKLE	1017 HOT
0206 D PRATHAP CHANG	1018 DAKOI
0207 NG SAI PHUN	1019 DOI TAO
0301 PHITSANULOK	1101 M. MAE HONG SAN
0302 RAK PHIRAK	1102 PAI
0303 T BOT	1103 KHUN YUAM
0304 HAT TAKAN	1104 MAE LA NOI
0305 NONG THAI	1105 MAE SARIANG
0306 NG THONG	1201 M. LAMPHUN
0307 NG KRATHUM	1202 MAE THA
0308 NONG RAKAM	1203 PA SANG
0309 *EN NAPPANG	1204 BAN HONG
0401 * UTTARADIT	1205 LI
0402 *AK THA	1206 THUNG HUA CHANG
0403 NAM PAT	1301 M. TAK
0404 THA PLA	1302 THA SONG YANG
0405 LAPLAE	1303 MAE RAMAT
0406 TRON	1304 SAM NGAO
0407 PHICHAI	1305 BAN TAK
0408 BAN KHOK	1306 MAE SOT
0501 *. PHRAE	1307 UMPHANG
0502 SONG	1308 PHOP PHRA
0503 RONG KWANG	1401 M. SUKHOTHAI
0504 DEN CHAI	1402 SI SATCHANALAI
0505 LONG	1403 THUNG SA.IAM
0506 S NG MEN	1404 SWANKHALOK
0507 WANG CHIN	1405 SI SAWANG
0601 * LAMPANG	1406 KONG KRAILAT
0602 WANG NUA	1407 KHIRI MAT
0603 CHAE HOM	1408 BAN DAN LAN HOI
0604 NONG	1409 SI NAKHON
0605 HANG CHAT	1501 M. KAMPHAENG PHET
0606 KE KHA	1502 PHRAN KRATAI
0607 MAE THA	1503 KHLONG KHLUNG
0608 SAP PRAP	1504 KHANU WARALAKSABURI
0609 MOEN	1505 SAI NGAM
0610 MAE PHRIK	1506 KLONG LAN
0611 SOEM NGAM	1507 LAN KRABU
0612 KE KO	1601 M. UTHAI THANI
0701 * NAN	1602 SAWANG AROM
0702 THUNG CHANG	1603 THAP THAN
0703 CHIANG KLANG	1604 NONG KHAYANG
0704 PUA	1605 NONG CHANG
0705 THA WANG PHA	1606 BAN RAI
0706 MAE CHARIM	1607 LAN SAK
0707 SA	1701 M. PHETCHABUN
0708 NA NOI	1702 LOM KAO
0709 BAN LUANG	1703 LOM SAK
0710 NA MUEN	1704 NONG PHAI
0801 * PHAYAO	1705 WICHIAN BURI
0802 CHIANG KHAM	1706 CHOR DAEN
0803 PONG	1707 SI THEP
0804 CHIANG MUAN	1708 BUNG SAM PHAN
0805 CHUN	1709 NAM NAO
0806 DOK KHAM TAI	
0807 MAE CHAI	
0901 M. CHIANG RAI	
0902 MAE SAI	
0903 CHIANG SAEN	
0904 CHIANG KHONG	
0905 MAE CHAN	
0906 THOENG	
0907 PA DAET	
0908 PHAN	
0909 MAE SUAI	
0910 WIANG PA PAO	
0911 WIANG CHAI	

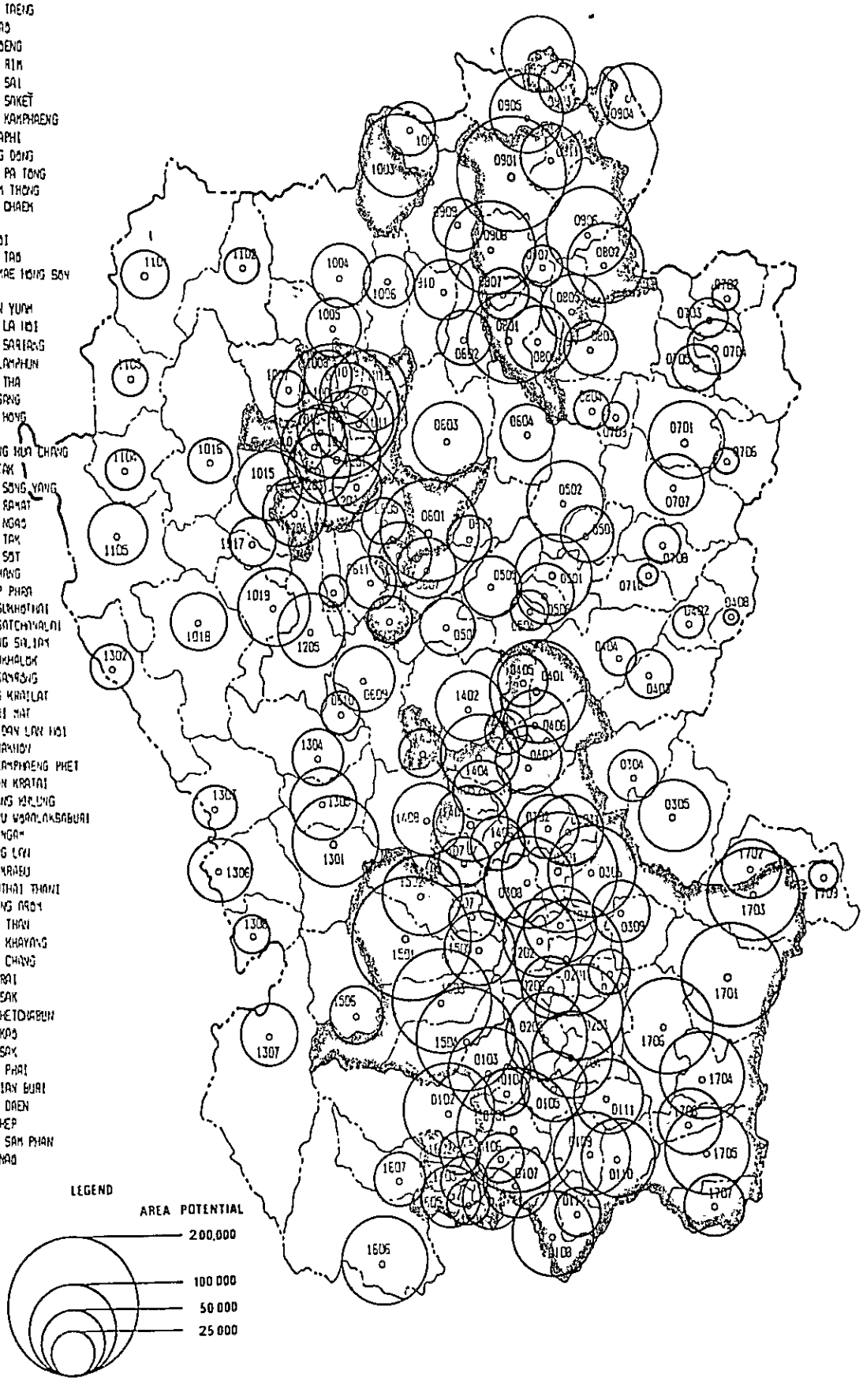


Table 3-1 VALUES BY CRITERIA AND AGGREGATED AREA POTENTIALS: WHOLE COUNTRY BY CHANGWAT

Amphoe \ Criteria	Future Land Potential	Performance of Major Productive Sectors	Levels of Urban Activity/ Services	Population Factor	Aggregated Area Potentials
101 NAKHON SAWAN	629	1085	939	904	959
102 PHICHIT	1413	730	517	515	843
103 PHITSANULOK	1003	695	895	768	900
104 UTTARADIT	276	330	306	431	284
105 PHRAE	210	331	336	385	260
106 LAMPANG	576	420	728	506	555
107 NAN	237	279	292	335	224
108 PHAYAO	410	408	309	405	342
109 CHIANG RAI	633	792	363	788	661
110 CHIANG MAI	961	885	1738	813	1216
111 MAE HONG SON	211	97	87	133	36
112 LAMPHUN	415	379	240	263	271
113 TAK	542	241	433	205	308
114 SUKHOTHAI	614	643	379	523	534
115 KAMPHAENG PHET	1148	549	249	661	670
116 UTHAI THANI	545	413	240	285	327
117 PHETCHABUN	264	1325	426	867	754
202 CHAI NAT	327	404	280	313	279
203 NONTHABURI	155	162	470	391	234
204 PATHUM THANI	185	339	152	326	181
205 AYUTTHAYA	363	617	808	552	588
206 LOP BURI	242	766	834	550	605
207 SAMUT PRAKAN	155	211	800	454	389
208 SARABURI	188	1318	686	463	685
209 SING BURI	155	279	189	201	127
210 ANG THONG	319	260	254	230	200
211 CHANTHABURI	299	193	854	364	336
212 CHACHOENGSAO	684	597	461	497	558
213 CHON BURI	300	874	1589	679	924
214 TRAT	313	77	281	167	131
215 NAKHON NAYOK	235	258	184	195	141
216 PRACHIN BURI	965	647	496	654	717
217 RAYONG	313	499	470	412	392
218 KANCHANABURI	1789	1429	856	561	1288
219 NAKHON PATHOM	649	456	764	547	612
220 PRACHUAP KHIRI KHAN	370	528	443	435	417
221 PHETCHABURI	439	371	827	339	478
222 RATCHABURI	465	892	997	607	778
223 SAMUT SONGKHRAM	341	70	293	188	147
224 SAMUT SAKHON	155	163	571	261	226
225 SUPHAN BURI	863	1201	631	649	895
301 KALASIN	1050	644	409	704	731
302 KHON KAEN	1036	966	923	1161	1121
303 CHAIYAPHUM	786	712	272	837	670
304 NAKHON PHANOM	594	521	371	713	546
305 NAKHON RATCHASIMA	1290	1701	1482	2305	1941
306 BURI RAM	982	793	371	1099	867
307 MAHA SARAKHAM	823	650	424	643	589
308 ROI ET	615	726	403	1087	738
309 LOEI	416	261	216	442	283
310 SI SA KET	624	697	312	1018	683
311 SAKON NAKHON	687	595	374	703	594
312 SURIN	729	699	441	964	739
313 NONG KHAI	212	417	360	724	398
314 UDON THANI	804	1146	1047	1278	1178
315 UBON RATCHATHANI	1540	1116	1212	1522	1549
316 YASOTHON	423	341	247	481	330
401 KRABI	382	126	858	238	364
402 CHUMPHON	425	156	331	356	262
403 TRANG	449	268	591	393	394
404 NAKHON SI THAMMARAT	1295	1439	1208	1207	1445
405 NARATHIWAT	1070	329	533	428	595
406 PATTANI	530	182	479	437	372
407 PHANGNGA	306	1030	250	181	414
408 PHATTHALUNG	360	298	304	412	294
409 PHUKET	161	498	552	143	288
410 YALA	501	195	897	273	383
411 RANONG	178	326	583	112	241
412 SONGKHLA	543	679	1782	792	1032
413 SATUN	208	68	157	192	86
414 SURAT THANI	1173	547	694	581	788

Table 3-2 AREA POTENTIALS IN THE ORDER OF MAGNITUDE: WHOLE COUNTRY BY CHANGWAT

(1) Future Land Potential

Order	Amphoe Code No. and Name	Potential
1	218 KANCHANABURI	1789
2	315 UBON RATCHATHANI	1540
3	102 PHICHIT	1413
4	404 NAKHON SI THAMMARAT	1295
5	305 NAKHON RATCHASIMA	1290
6	414 SURAT THANI	1173
7	115 KAMPHAENG PHET	1148
8	405 NARATHIWAT	1070
9	301 KALASIN	1050
10	302 KHON KAEN	1036
11	103 PHITSANULOK	1003
12	306 BURI RAM	982
13	216 PRACHIN BURI	965
14	110 CHIANG MAI	961
15	225 SUPHAN BURI	863
16	314 UDON THANI	804
17	303 CHAIYAPHUM	786
18	312 SURIN	729
19	311 SAKON NAKHON	687
20	212 CHACHOENGSAO	684
21	219 NAKHON PATHOM	649
22	109 CHIANG RAI	633
23	101 NAKHON SAWAN	629
24	310 SI SA KET	624
25	307 MAHA SARAKHAM	623
26	308 ROI ET	615
27	114 SUKHOTHAI	614
28	304 NAKHON PHANOM	594
29	106 LAMPANG	576
30	116 UTHAI THANI	545
31	412 SONGKHLA	543
32	113 TAK	542
33	406 PATTANI	530
34	410 YALA	501
35	222 RATCHABURI	465
36	403 TRANG	449
37	221 PHETCHABURI	439
38	402 CHUMPHON	425
39	316 YASOTHON	423
40	309 LOEI	416
41	112 LAMPHUN	415
42	108 PHAYAO	410
43	401 KRABI	382
44	220 PRACHUAP KHIRI KHAN	370
45	205 AYUTTHAYA	363
46	408 PHATTHALUNG	360
47	223 SAMUT SONGKHRAM	341
48	202 CHAI NAT	327
49	210 ANG THONG	319
50	217 RAYONG	313
51	214 TRAT	313
52	407 PHANGNGA	306
53	213 CHON BURI	300
54	211 CHANTHABURI	299
55	104 UTTARADIT	276
56	117 PHETCHABUN	264
57	206 LOP BURI	242
58	107 NAN	237
59	215 NAKHON NAYOK	235
60	313 NONG KHAI	212
61	111 MAE HONG SON	211
62	105 PHRAE	210
63	413 SATUN	208
64	208 SARABURI	188
65	204 PATHNM THANI	185
66	411 RANONG	178
67	409 PHUKET	161
68	203 NONTHABURI	155
69	207 SAMUT PRAKAN	155
70	209 SING BURI	155
71	224 SAMUT SAKHON	155

(2) Performance of Major Productive Sectors

Order	Amphoe Code No. and Name	Potential
1	305 NAKHON RATCHASIMA	1701
2	404 NAKHON SI THAMMARAT	1439
3	218 KANCHANABURI	1429
4	117 PHETCHABUN	1325
5	208 SARABURI	1318
6	225 SUPHAN BURI	1201
7	314 UDON THANI	1146
8	315 UBON RATCHATHANI	1116
9	101 NAKHON SAWAN	1085
10	407 PHANGNGA	1030
11	302 KHON KAEN	966
12	222 RATCHABURI	892
13	110 CHIANG MAI	885
14	213 CHON BURI	874
15	306 BURI RAM	799
16	109 CHIANG RAI	792
17	206 LOP BURI	766
18	102 PHICHIT	730
19	308 ROI ET	726
20	303 CHAIYAPHUM	712
21	312 SURIN	699
22	310 SI SA KET	697
23	103 PHITSANULOK	695
24	412 SONGKHLA	679
25	307 MAHA SARAKHAM	650
26	216 PRACHIN BURI	647
27	301 KALASIN	644
28	114 SUKHOTHAI	643
29	205 AYUTTHAYA	617
30	212 CHACHOENGSAO	597
31	311 SAKON NAKHON	595
32	115 KAMPHAENG PHET	549
33	414 SURAT THANI	547
34	220 PRACHUAP KHIRI KHAN	528
35	304 NAKHON PHANOM	521
36	217 RAYONG	499
37	409 PHUKET	498
38	219 NAKHON PATHOM	456
39	106 LAMPANG	420
40	313 NONG KHAI	417
41	116 UTHAI THANI	413
42	108 PHAYAO	408
43	202 CHAI NAT	404
44	112 LAMPHUN	379
45	221 PHETCHABURI	371
46	316 YASOTHON	341
47	204 PATHNM THANI	339
48	105 PHRAE	331
49	104 UTTARADIT	330
50	405 NARATHIWAT	329
51	411 RANONG	326
52	408 PHATTHALUNG	298
53	209 SING BURI	279
54	107 NAN	279
55	403 TRANG	268
56	309 LOEI	261
57	210 ANG THONG	260
58	215 NAKHON NAYOK	258
59	113 TAK	241
60	207 SAMUT PRAKAN	211
61	410 YALA	195
62	211 CHANTHABURI	193
63	406 PATTANI	182
64	224 SAMUT SAKHON	163
65	203 NONTHABURI	162
66	402 CHUMPHON	156
67	401 KRABI	126
68	111 MAE HONG SON	97
69	214 TRAT	77
70	223 SAMUT SONGKHRAM	70
71	413 SATUN	68

Table 3-2 AREA POTENTIALS IN THE ORDER OF MAGNITUDE: WHOLE COUNTRY BY CHANGWAT (Continued)

(3) Urban Activities/Services

Order	Amphoe Code No. and Name	Potential
1	412 SONGKHLA	1782
2	110 CHIANG MAI	1738
3	213 CHON BURI	1589
4	305 NAKHON RATCHASIMA	1482
5	315 UBON RATCHATHANI	1212
6	404 NAKHON SI THAMMARAT	1208
7	314 UDON THANI	1047
8	222 RATCHABURI	997
9	101 NAKHON SAWAN	939
10	302 KHON KAEN	923
11	103 PHITSANULOK	895
12	401 KRABI	858
13	218 KANCHANABURI	856
14	206 LOP BURI	834
15	221 PHETCHABURI	827
16	205 AYUTTHAYA	808
17	207 SAMUT PRAKAN	800
18	219 NAKHON PATHOM	764
19	106 LAMPANG	728
20	410 YALA	697
21	414 SURAT THANI	694
22	208 SARABURI	686
23	211 CHANTHABURI	654
24	225 SUPHAN BURI	631
25	403 TRANG	591
26	411 RANONG	583
27	224 SAMUT SAKHON	571
28	409 PHUKET	552
29	405 NARATHIWAT	533
30	102 PHICHIT	517
31	216 PRACHIN BURI	496
32	406 PATTANI	479
33	203 NONTHABURI	470
34	217 RAYONG	470
35	212 CHACHOENGSAO	461
36	220 PRACHUAP KHIRI KHAN	443
37	312 SURIN	441
38	113 TAK	433
39	117 PHETCHABUN	426
40	307 MAHA SARAKHAM	424
41	301 KALASIN	409
42	308 ROI ET	403
43	114 SUKHOTHAI	379
44	311 SAKON NAKHON	374
45	304 NAKHON PHANOM	371
46	306 BURI RAM	371
47	109 CHIANG RAI	363
48	313 NONG KHAI	360
49	105 PHRAE	336
50	402 CHUMPHON	331
51	310 SI SA KET	312
52	108 PHAYAO	309
53	104 UTTARADIT	306
54	408 PHATTHALUNG	304
55	223 SAMUT SONGKHRAM	293
56	107 NAN	292
57	214 TRAT	281
58	202 CHAI NAT	280
59	303 CHAIYAPHUM	272
60	210 ANG THONG	254
61	407 PHANGNGA	250
62	115 KAMPHAENG PHET	249
63	316 YASOTHON	247
64	116 UTHAI THANI	240
65	112 LAMPHUN	240
66	309 LOEI	216
67	209 SING BURI	189
68	215 NAKHON NAYOK	184
69	413 SATUN	157
70	204 PATHUM THANI	152
71	111 MAE HONG SON	87

(4) Population Factor

Order	Amphoe Code No. and Name	Potential
1	305 NAKHON RATCHASIMA	2306
2	315 UBON RATCHATHANI	1622
3	314 UDON THANI	1278
4	404 NAKHON SI THAMMARAT	1207
5	302 KHON KAEN	1161
6	306 BURI RAM	1099
7	308 ROI ET	1087
8	310 SI SA KET	1018
9	312 SURIN	964
10	101 NAKHON SAWAN	904
11	117 PHETCHABUN	867
12	303 CHAIYAPHUM	837
13	110 CHIANG MAI	813
14	412 SONGKHLA	792
15	109 CHIANG RAI	788
16	103 PHITSANULOK	768
17	313 NONG KHAI	724
18	304 NAKHON PHANOM	713
19	301 KALASIN	704
20	311 SAKON NAKHON	703
21	213 CHON BURI	679
22	115 KAMPHAENG PHET	661
23	216 PRACHIN BURI	654
24	225 SUPHAN BURI	649
25	307 MAHA SARAKHAM	643
26	222 RATCHABURI	607
27	414 SURAT THANI	581
28	218 KANCHANABURI	561
29	205 AYUTTHAYA	552
30	206 LOP BURI	550
31	219 NAKHON PATHOM	547
32	114 SUKHOTHAI	523
33	102 PHICHIT	515
34	106 LAMPANG	506
35	212 CHACHOENGSAO	497
36	316 YASOTHON	481
37	208 SARABURI	463
38	207 SAMUT PRAKAN	454
39	309 LOEI	442
40	406 PATTANI	437
41	220 PRACHUAP KHIRI KHAN	435
42	104 UTTARADIT	431
43	405 NARATHIWAT	428
44	408 PHATTHALUNG	412
45	217 RAYONG	412
46	108 PHAYAO	405
47	403 TRANG	393
48	203 NONTHABURI	391
49	105 PHRAE	385
50	211 CHANTHABURI	364
51	402 CHUMPHON	356
52	221 PHETCHABURI	339
53	107 NAN	335
54	204 PATHUM THANI	326
55	202 CHAI NAT	313
56	116 UTHAI THANI	285
57	410 YALA	273
58	112 LAMPHUN	263
59	224 SAMUT SAKHON	261
60	401 KRABI	238
61	210 ANG THONG	230
62	113 TAK	205
63	209 SING BURI	201
64	215 NAKHON NAYOK	195
65	413 SATUN	192
66	223 SAMUT SONGKHRAM	188
67	407 PHANGNGA	181
68	214 TRAT	167
69	409 PHUKET	143
70	111 MAE HONG SON	133
71	411 RANONG	112

Table 3-2 AREA POTENTIALS IN THE ORDER OF MAGNITUDE: WHOLE COUNTRY OF CHANGWAT (Continued)

(5) Total Potential

Order	Amphoe Code No. and Name	Potential
1	305 NAKHON RATCHASIMA	1541
2	315 UBON RATCHATHANI	1549
3	404 NAKHON SI THAMMARAT	1445
4	218 KANCHANABURI	1288
5	110 CHIANG MAI	1216
6	314 UDON THANI	1178
7	302 KHON KAEN	1121
8	412 SONGKHLA	1032
9	101 NAKHON SAWAN	959
10	203 CHON BURI	924
11	103 PHITSANULOK	900
12	225 SUPHAN BURI	895
13	306 BURI RAM	867
14	102 PHICHIT	843
15	414 SURAT THANI	788
16	222 RATCHABURI	778
17	117 PHETCHABUN	754
18	312 SURIN	739
19	308 ROI ET	738
20	301 KALASIN	731
21	216 PRACHIN BURI	717
22	208 SARABURI	685
23	310 SI SA KET	683
24	303 CHAIYAPHUM	670
25	115 KAMPHAENG PHET	670
26	109 CHIANG RAI	661
27	219 NAKHON PATHOM	612
28	206 LOP BURI	605
29	405 NARATHIWAT	595
30	311 SAKON NAKHON	594
31	307 MAHA SARAKHAM	589
32	205 AYUTTHAYA	586
33	212 CHACHOENGSAO	559
34	106 LAMPANG	555
35	304 NAKHON PHANOM	546
36	114 SUKHOTHAI	534
37	221 PHETCHABURI	478
38	220 PRACHUAP KHIRI KHAN	417
39	407 PHANGNGA	414
40	313 NONG KHAI	398
41	403 TRANG	394
42	217 RAYONG	392
43	410 YALA	383
44	406 PATTANI	372
45	207 SAMUT PRAKAN	369
46	401 KRABI	364
47	108 PHAYAO	342
48	211 CHANTHABURI	336
49	316 YASOTHON	330
50	116 UTHAI THANI	327
51	113 TAK	308
52	408 PHATTHALUNG	294
53	409 PHUKET	282
54	104 UTTARADIT	284
55	309 LOEI	283
56	202 CHAI NAT	279
57	112 LAMPHUN	271
58	402 CHUMPHON	262
59	105 PHRAE	260
60	411 RANONG	241
61	203 NONTHABURI	234
62	224 SAMUT SAKHON	226
63	107 NAN	224
64	210 ANG THONG	200
65	204 PATHUM THANI	181
66	223 SAMUT SONGKHRAM	147
67	215 NAKHON NAYOK	141
68	214 TRAT	131
69	209 SING BURI	127
70	413 SATUN	66
71	111 MAE HONG SON	38

Table 3-3 VALUES BY CRITERIA AND AGGREGATED AREA POTENTIALS: AMPHOE

Amphoe \ Criteria	Future Land Potential	Performance of Major Productive Sectors	Levels of Urban Activity/ Services	Population Factor	Aggregated Area Potentials
0101 M. NAKHON SAWAN	56917	97590	258030	188142	179537
0102 LAT YAO	106368	117673	67948	135155	121863
0103 BANPHOT PHISAI	95500	83617	52709	96224	88929
0104 KAO LIEO	29534	29604	44006	39101	27177
0105 CHUMSAENG	31921	75204	63473	78682	62750
0106 KROK PHRA	29998	29902	45873	40324	28457
0107 PHAYUHA KHIRI	39039	80988	69165	53345	60509
0108 TAKHLI	20379	162140	107110	60778	96359
0109 THA TAKO	80824	105359	55557	58091	79537
0110 PHAISALI	64735	95417	51981	74192	75062
0111 NONG BUA	46896	104003	48471	55724	64682
0112 TAK FA	29513	57859	47337	19172	31077
0201 M. PHICHIT	205772	135609	85183	128591	164393
0202 SAM NGAM	106997	68878	48186	57884	73606
0203 TAPHAN HIN	130585	112033	76429	111569	123017
0204 BANG MUN NAK	94272	115326	59863	60301	89498
0205 PHO THALE	134185	117175	46393	40261	92240
0206 PHO PRATHAP CHANG	70659	42600	42297	41586	45422
0207 WANG SAI PHUN	32176	18259	40064	45854	25218
0301 M. PHITSANULOK	208082	106382	229104	182930	214706
0302 PHROM PHIRAM	23073	88372	55758	58364	54875
0303 WAT BOT	150783	35974	47043	38369	69852
0304 CHAT TRAKAN	72443	20295	41447	32838	35412
0305 NAKHON THAI	80599	77568	47212	54453	66257
0306 WANG THONG	145407	92903	83280	98155	112757
0307 BANG KRATHUM	126159	43973	48427	60913	72651
0308 BANG RAKAM	84612	98614	85689	131198	106232
0309 NOEN MAPRANG	69241	34602	42822	67866	51201
0401 M. UTTARADIT	47696	91285	150285	156106	128586
0402 FAK THA	27345	12894	41029	18796	13191
0403 NAM PAT	56352	27321	43842	27069	31278
0404 THA PLA	19802	20976	45769	31342	19082
0405 LAPLAE	35221	30140	46194	61730	37493
0406 TRON	80200	71490	50267	54586	58517
0407 PHICHAI	56770	69162	49695	67747	60787
0408 BAN KHOK	19802	1068	37484	13436	3761
0501 M. PHRAE	37160	81960	99697	81870	79835
0502 SONG	63956	147231	49419	65934	88427
0503 RONG KWANG	33675	46460	50242	54806	41447
0504 DEN CHAI	19802	14005	59191	30752	21043
0505 LONG	60618	45112	49304	50879	48337
0506 SUNG MEN	20686	43059	54511	77643	45068
0507 WANG CHIN	59634	44661	44618	34769	40948
0601 M. LAMPANG	111610	85884	192141	123301	150376
0602 WANG NUA	46926	44465	49696	41881	40701
0603 CHAE HOM	91570	67994	52383	53033	67968
0604 NGAO	52682	43184	47082	31270	41127
0605 HANG CHAT	27893	41981	49239	41964	33435
0606 KO KHA	57064	49704	60455	58900	55054
0607 MAE THA	30122	71763	47089	47359	45153
0608 SOP PRAP	39203	28288	44395	29044	26740
0609 THOEN	91654	52023	54481	38906	55333
0610 MAE PHRIK	58581	11264	43964	18277	23801
0611 SOEM NGAM	67293	36781	44117	27685	38155
0612 MAE MO	66355	17904	38359	21957	27951

Table 3-3 VALUES BY CRITERIA AND AGGREGATED AREA POTENTIALS: AMPHOE (Continued)

Amphoe \ Criteria	Future Land Potential	Performance of Major Productive Sectors	Levels of Urban Activity/ Services	Population Factor	Aggregated Area Potentials
0701 M. NAN	29639	89111	87866	79996	75157
0702 THUNG CHANG	26732	7403	42439	17159	11054
0703 CHIANG KLANG	29153	19570	46786	25806	20221
0704 PUA	38031	52007	49617	45821	41545
0705 THA WANG PHA	34909	35376	45733	41452	32237
0706 MAE CHARIM	26424	2024	40895	17590	8794
0707 SA	60777	57309	53296	41554	50671
0708 NA NOI	20572	18239	45581	33908	19219
0709 BAN LUANG	36549	1327	38270	17495	11023
0710 NA MUEN	19802	551	38198	21616	6545
0801 M. PHAYAO	85785	111809	92638	98093	108297
0802 CHIANG KHAM	61914	80653	62845	114102	86092
0803 PONG	67894	34724	47511	32291	40525
0804 CHIANG MJAN	42886	5801	43974	22287	19435
0805 CHUN	57122	47547	54579	88849	62356
0806 DOK KHAM TAI	55990	68535	56541	73279	64433
0807 MAE CHAI	37715	32029	49529	55518	37994
0901 M. CHIANG RAI	108089	173154	135289	184113	172882
0902 MAE SAI	103532	43374	67499	70184	74485
0903 CHIANG SAEN	31657	32551	51444	59379	38073
0904 CHIANG KHONG	59045	60820	51750	48009	52894
0905 MAE CHAN	42309	98835	59199	85883	75029
0906 THOENG	71020	133302	80051	110573	104515
0907 PA DAET	21777	23332	45980	41064	23823
0908 PHAN	81931	164446	76120	107823	116271
0909 MAE SUAI	35576	38489	47194	42011	34164
0910 WIANG PA PAO	26343	74625	53249	61116	51467
0911 WIANG CHAI	46331	58756	52728	70625	55824
1001 M. CHIANG MAI	20379	24159	408327	299214	229655
1002 MAE AI	39864	39124	49128	46789	38031
1003 FANG	53882	111742	84605	78939	82654
1004 CHIANG DAO	71413	48220	51390	49731	53269
1005 MAE TAENG	57198	56618	49933	37450	46770
1006 PHRAO	45853	44022	46208	34587	36624
1007 SAMOENG	20412	30053	41102	20413	17118
1008 MAE RIM	32822	28394	56557	58773	38577
1009 SAN SAI	30778	49864	51792	66261	45938
1010 DOI SAKET	169971	49314	50455	42308	83611
1011 SAN KAMPHAENG	36550	80609	59194	64908	60085
1012 SARAPHI	22880	45056	53255	119852	60012
1013 HANG DONG	20804	39308	49753	68692	39245
1014 SAN PA TONG	28340	81962	62319	87138	66233
1015 CHOM THONG	44606	85730	55467	62805	62593
1016 MAE CHAEM	24917	37103	43653	33238	26069
1017 HOT	51356	20903	45729	30779	29345
1018 OMKOI	94442	40723	42815	12900	43341
1019 DOI TAO	95217	119073	42727	22674	72857
1101 M. MAE HONG SON	54144	14244	49508	21561	29573
1102 PAI	27689	24407	41225	16808	16503
1103 KHUN YUAM	42946	4630	41316	22798	17022
1104 MAE LA NOI	32234	21906	42727	25958	20722
1105 MAE SARIANG	22968	65813	52088	68647	49534
1201 M. LAMPHUN	40612	117171	99949	131695	103328
1202 MAE THA	42618	53526	45160	31869	37456
1203 PA SANG	40386	84822	50253	72203	62213
1204 BAN HONG	53690	99581	50363	42651	61821
1205 LI	124473	46380	49994	40461	86748
1206 THUNG HUA CHANG	41758	1790	37570	18463	12998

Table 3-3 VALUES BY CRITERIA AND AGGREGATED AREA POTENTIALS: AMPHOE (Continued)

Amphoe \ Criteria	Future Land Potential	Performance of Major Productive Sectors	Levels of Urban Activity/ Services	Population Factor	Aggregated Area Potentials
1301 M. TAK	133659	88657	93345	89993	108074
1302 THA SONG YANG	19802	57830	41511	15181	24544
1303 MAE RAMAT	42270	18943	43108	33237	25619
1304 SAM NGAO	89440	22069	45858	24690	40409
1305 BAN TAK	119968	58418	46852	30408	84866
1306 MAE SOT	21443	77620	65884	59656	54548
1307 UMPHANG	129260	16704	40626	13720	46475
1308 PHOP PHRA	53851	10696	38097	14118	18708
1401 M. SUKHOTHAI	19802	77369	87422	101521	74992
1402 SI SATCHANALAI	26769	97144	49043	65232	59084
1403 THUNG SALIAM	19802	45263	48301	44772	32459
1404 SWANKHALOK	80788	73860	68364	97228	86333
1405 SI SAMRONG	22939	59520	54646	71830	49341
1406 KONG KRAILAT	34422	53305	43533	61933	44109
1407 KHIRI MAT	49427	33375	48205	39048	35420
1408 BAN DAN LAN HOI	171965	20027	42011	25029	65991
1409 SI NAKHON	22993	17698	49503	45165	24868
1501 M. KAMPHAENG PHET	177406	178753	137316	189032	206733
1502 PHRAN KRATAI	129552	59747	56685	71649	85467
1503 KHLONG KHLUNG	171548	139062	76837	84328	136696
1504 KHANU WORALAKSABURI	136114	123927	79359	108958	129578
1505 SAI NGAM	121104	41875	51305	52616	68606
1506 KLONG LAN	87037	23853	40364	31212	40545
1507 LAN KRABU	32651	39252	39986	43318	31485
1601 M. UTHAI THANI	34230	24883	78473	59218	45302
1602 SAWANG AROM	30190	29249	41476	32177	24135
1603 THAP THAN	29805	41005	43119	33193	28798
1604 NONG KHAYANG	52219	21671	41291	19182	24557
1605 NONG CHANG	64100	45195	47999	45802	47400
1606 BAN RAI	121768	109020	52933	87802	103377
1607 LAN SAK	40386	42124	38089	46071	35295
1701 M. PHETCHABUN	82196	172618	96972	122718	137602
1702 LOM KAO	54416	50683	52398	51909	49496
1703 LOM SAK	40475	148278	82468	137307	115676
1704 NONG PHAI	20375	136853	68902	102338	89069
1705 WICHIAN BURI	24158	170618	68907	85249	95869
1706 CHON DAEN	144276	91443	60887	126875	120646
1707 SI THEP	53082	56622	51214	42663	47562
1708 BUNG SAM PHAN	22608	79701	56673	65734	54586
1709 NAM NAO	43464	-1042	38169	16271	12094

Table 3-4 AREA POTENTIALS IN THE ORDER OF MAGNITUDE: AMPHOE

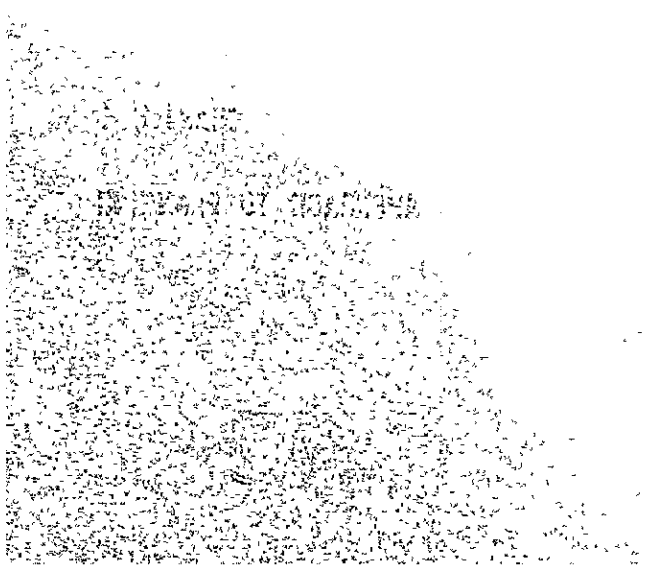
Order	Amphoe Code No. and Name	Total Potentials		Order	Amphoe Code No. and Name	Total Potentials	
1	1001 M. CHIANG MAI	229855	230000	61	0407 PHICHAI	60787	61000
2	0301 M. PHITSANULOK	214706	215000	62	0107 PHAYUHA KHIRI	60509	61000
3	1501 M. KAMPHAENG PHET	206733	207000	63	1011 SAN KAMPHAENG	60085	60000
4	0101 M. NAKHON SAWAN	179537	180000	64	1012 SARAPHI	60012	60000
5	0901 M. CHIANG RAI	172882	173000	65	1402 SI SATCHANALAI	59064	59000
6	0201 M. PHICHIT	164393	164000	66	0406 TRON	58517	59000
7	0601 M. LAMPANG	150376	150000	67	0911 WIANG CHAI	55824	56000
8	1701 M. PHETCHABUN	137602	138000	68	0609 THOEN	55333	55000
9	1503 KHLONG KHLUNG	136696	137000	69	0606 KO KHA	55054	55000
10	1504 KHANU WORALAKSABURI	129578	130000	70	0302 PHROM PHIRAM	54875	55000
11	0401 M. UTTARADIT	128586	129000	71	1708 BUNG SAM PHAN	54586	55000
12	0203 TAPHAN HIN	123017	123000	72	1306 MAE SOT	54548	55000
13	0102 LAT YAO	121863	122000	73	1004 CHIANG DAO	53269	53000
14	1706 CHON DAEN	120646	121000	74	0904 CHIANG KHONG	52894	53000
15	0908 PHAN	116271	116000	75	0910 WIANG PA PAO	51467	51000
16	1703 LOM SAK	115676	116000	76	0309 NOEN MAPRANG	51201	51000
17	0306 WANG THONG	112757	113000	77	0707 SA	50671	51000
18	1201 M. LAMPHUN	109328	109000	78	1105 MAE SARIANG	49534	50000
19	0801 M. PHAYAO	108297	108000	79	1702 LOM KAO	49498	49000
20	1301 M. TAK	108074	108000	80	1405 SI SAMRONG	49341	49000
21	0308 BANG RAKAM	106232	106000	81	0505 LONG	48337	48000
22	0906 THOENG	104515	105000	82	1707 SI THEP	47562	48000
23	1606 BAN RAI	103377	103000	83	1605 NONG CHANG	47400	47000
24	0108 TAKHLI	98359	98000	84	1005 MAE TAENG	46770	47000
25	1705 WICHIAN BURI	95869	96000	85	1307 UMPHANG	46475	46000
26	0205 PHO THALE	92241	92000	86	1009 SAN SAI	45938	46000
27	0204 BANG MUN NAK	89498	89000	87	0206 PHO PRATHAP CHANG	45422	45000
28	1704 NONG PHAI	89069	89000	88	1601 M. UTHAI THANI	45303	45000
29	0103 BANPHOT PHISAI	88929	89000	89	0607 MAE THA	45153	45000
30	0502 SONG	88427	88000	90	0506 SUNG MEN	45068	45000
31	1404 SWANKHALOK	88333	88000	91	1406 KONG KRAILAT	44109	44000
32	0802 CHIANG KHAM	88092	88000	92	1018 OMKOI	43341	43000
33	1502 PHRAN KRATAI	85467	85000	93	0704 PUA	41545	42000
34	1010 DOI SAKET	83611	84000	94	0503 RONG KWANG	41447	41000
35	1003 FANG	82654	83000	95	0604 NGAO	41127	41000
36	0501 M. PHRAE	79835	80000	96	0507 WANG CHIN	40948	41000
37	0109 THA TAKO	79537	80000	97	0602 WANG NUA	40701	41000
38	0701 M. NAN	75157	75000	98	1506 KLONG LAN	40545	41000
39	0110 PHAISALI	75062	75000	99	0803 PONG	40529	41000
40	0905 MAE CHAN	75029	75000	100	1304 SAM NGAO	40408	40000
41	1401 M. SUKHOTHAI	74992	75000	101	1013 HANG DONG	39245	39000
42	0902 MAE SAI	74485	74000	102	1008 MAE RIM	38577	39000
43	0202 SAM NGAM	73606	74000	103	0611 SOEM NGAM	38155	38000
44	1019 DOI TAO	72857	73000	104	0903 CHIANG SAEN	38073	38000
45	0307 BANG KRATHUM	72651	73000	105	1002 MAE AI	38031	38000
46	0303 WAT BOT	69692	70000	106	0807 MAE CHAI	37994	38000
47	1505 SAI NGAM	68606	69000	107	0405 LAPLAE	37493	37000
48	0603 CHAE HOM	67968	68000	108	1202 MAE THA	37456	37000
49	1205 LI	66748	67000	109	1006 PHRAO	36624	37000
50	0305 NAKHON THAI	66257	66000	110	1407 KHIRI MAT	36420	36000
51	1014 SAN PA TONG	66233	66000	111	0304 CHAT TRAKAN	35412	35000
52	1408 BAN DAN LAN HOI	65991	66000	112	1607 LAN SAK	35295	35000
53	1305 BAN TAK	64866	65000	113	0909 MAE SUAI	34165	34000
54	0111 NONG BUA	64682	65000	114	0605 HANG CHAT	33435	33000
55	0806 DOK KHAM TAI	64433	64000	115	1403 THUNG SALIAM	32459	32000
56	0105 CHUMSAENG	62750	63000	116	0705 THA WANG PHA	32237	32000
57	1015 CHOM THONG	62593	63000	117	1507 LAN KRABU	31485	31000
58	0805 CHUN	62356	62000	118	0403 NAM PAT	31278	31000
59	1203 PA SANG	62213	62000	119	0112 TAK FA	31077	31000
60	1204 BAN HONG	61821	62000	120	1101 M. MAE HONG SON	29574	30000

Table 3-4 AREA POTENTIALS IN THE ORDER OF MAGNITUDE: AMPHOE (Continued)

Order	Amphoe Code No. and Name	Total Potentials	
121	1017 HOT	29345	29000
122	1603 THAP THAN	28798	29000
123	0106 KROK PHRA	28457	28000
124	0612 MAE MO	27951	28000
125	0104 KAO LIEO	27177	27000
126	0608 SOP PRAP	26740	27000
127	1016 MAE CHAEM	26069	26000
128	1303 MAE RAMAT	25619	26000
129	0207 WANG SAI PHUN	25218	25000
130	1409 SI NAKHON	24888	25000
131	1604 NONG KHAYANG	24557	25000
132	1302 THA SONG YANG	24544	25000
133	1602 SAWANG AROM	24135	24000
134	0907 PA DAET	23823	24000
135	0610 MAE PHRIK	23801	24000
136	0504 DEN CHAI	21043	21000
137	1104 MAE LA NOI	20723	21000
138	0703 CHIANG KLANG	20221	20000
139	0804 CHIANG MUAN	19435	19000
140	0708 NA NOI	19219	19000
141	0404 THA PLA	19082	19000
142	1308 PHOP PHRA	18708	19000
143	1007 SAMOENG	17118	17000
144	1103 KHUN YUAM	17022	17000
145	1102 PAI	16503	17000
146	0402 FAK THA	13191	13000
147	1206 THUNG HUA CHANG	12998	13000
148	1709 NAM NAO	12094	12000
149	0702 THUNG CHANG	11054	11000
150	0709 BAN LUANG	11023	11000
151	0706 MAE CHARIM	8794	9000
152	0710 NA MUEN	6545	7000
153	0408 BAN KHOK	3761	4000

CHAPTER 4

APPROACH TO PLANNING



CHAPTER 4

APPROACH TO PLANNING

4-1 DEVELOPMENT TARGET

From the analyses made in Chapters 2 and 3, the following implications to the road development for the Northern Region can be drawn. First, it is very important to strengthen rural-urban linkage within the Region. With rich water resources and comparatively high yield, crop diversification which is stressed in the National Plan, is a central and viable strategy for the agricultural development in the Northern Region. The agricultural diversification calls for linkage of production, processing and marketing, including foreign trade. The rural-urban linkage is warranted from the standpoint of urban development, too. Despite that Muang Chiang Mai is the second largest city in Thailand, its population is only one-fortieth as much as Bangkok and average level of urbanization of the Northern Region is lower than any other three regions. For the Northern Region, however, it does not seem sufficient to stress the development of "urban growth centers". Many other local centers need to be developed simultaneously so as to form a city system, including the "urban growth centers" of course, in order to keep surplus out-migration from flocking into Bangkok and raise agro-industries and other related urban activities for regional development. This city system, if it is to be fostered, demands hierarchic network of rural-urban linkages.

Second, access to high potential lands should be ensured. In the Northern Region, area of cultivable lands is much more limited than other regions due to mountainous topography. Environmental constraints are another factor of limitation in potential lands. Disordered encroachment of forest area is undesirable especially for the Northern Region which has watershed area of the Chao Phraya and other rivers.

The topographic and environmental constraints lead a greater emphasis on full utilization of high potential lands by providing access to markets and villages. Planned provision of access is necessary not only for enhancing agriculture but for forest preservation because administrative control alone can never stop forest encroachment and guided land use change appears more effective. Provision of access with irrigable area is proven to be most promising in the Region when many large-scale irrigation projects are underway.

Third, it should be recalled that, from macro-scopic viewpoint, Thailand seems to be left behind other countries, even some developing countries, in overall level of road development. In addition, the Northern Region is among the lowest compared with various national standards, as seen in Chapter 2. On the other hand, dependence on road transport has been increasing without diversified transport network of other modes. It should, therefore, be justified that road milage be increased especially at secondary or feeder roads levels. As the National Plan suggests, expansion of feeder road network leads to fuller utilization of arterial network, in general.

In view of challenge for road development described above, development targets have been set as under:

* To reinforce network of linkages between and within administrative, social and economic units of the region in order to encourage urban-rural interactions, inter-urban as well, and establish a physical frame for a balanced development of the region; and

* To ensure access for the areas which are endowed with potential resources, including high productive lands, thereby attaining maximum utilization of the region's resources for national economic development as well as improving living standard of the people in such areas.

4-2 PLANNING CRITERIA AND INDICATORS

The development targets need to be translated into a set of criteria for project identification so that functions of identified roads are consistent with the development targets.

Considering that Changwat and Amphoe are not only administrative but viable socio-economic unit in almost all cases, they are identified as basic areal unit to be used in criteria. In addition, hinterland of market is identified as another areal unit in order to take into account commodity flows.

Thus, the first target, namely, reinforcement of intra-regional linkages, is translated into the following criteria:

Criteria_1 To link among:

A. Centers of adjacent Amphoe (Inter-Adjacent Amphoe Linkage),
B. Centers of adjacent Changwat (Inter-Changwat Linkage), and
C. Changwat centers and its Amphoe (Intra-Changwat Linkage).

Criteria_2 To link centers of Amphoe within Market Zone with:

D. Market center (Intra-Market Zone Linkage).

Criteria 3 To link existing artery paved highways directly:

E. With centers of neighbouring Amphoe (Amphoe-Artery Road Linkage), and

F. In an East-West direction (Laterial-Type Linkage).

The second target, namely, ensuring access for high potential lands and people therein is translated into the following criteria:

Criteria 4 To ensure access to high potential lands by:

G. Improving existing unpaved roads with high development potential alongside (Improvement of DOH Unpaved Roads), ard

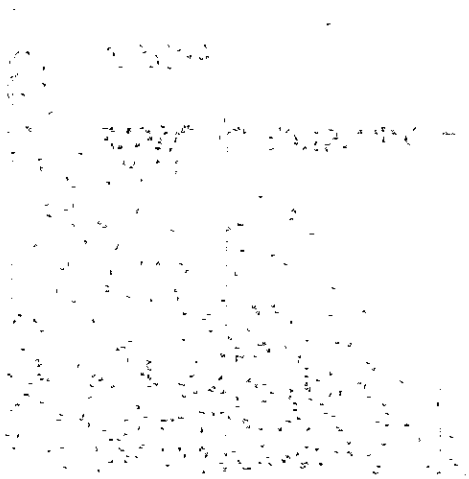
H. Providing better access with isolated area with high development potential, particularly in 8 Changwat in Lower North (Feeder Road Requirement).

Eight criteria should not be taken as a set of the necessary conditions to be met by candidate projects. Rather, each criterion is to be considered independently to correspond to each assessment of different types/functions of road.

Concrete indicators are necessary to identify priority links in the light of the criteria. Kind of indicators varies from one to another depending on criteria. In principle, however, the indicators employed in the Study are broadly categorized into two aspects: one is the level of physical accessibility of links and the other is the relative importance of links from socio-economic viewpoint on the basis of area potentials. Detailed specifications of respective indicators are described in the next Chapter.

CHAPTER 5

IDENTIFICATION OF ROUTES



CHAPTER 5

IDENTIFICATION OF ROUTES

5-1 PROCESS OF ROUTE IDENTIFICATION

Process of route identification based on the planning criteria proposed in 4-2 is shown in Figure 5-1.

As shown in the said figure, the study for route identification was carried out dividing it into following 2 steps:

i) Step I : The linkages or the road requirement areas to be analysed in the Step 2 were selected individually by each criterion mainly on a theoretical basis. The major indicators applied for assessment are: i) the level of accessibility on the links and ii) relative importance of interaction between nodes of each link, which are expressed by inter-nodal gravity or commodity flow volume, etc.

ii) Step II : Technical possibility of the improvement of the links or areas selected in the Step I were examined on the basis of topographic maps and the results of field reconnaissance. The routes thus determined were adjusted taking the DOH's comments into account and finally listed up separating them into short/medium term program and long term program.

5-2 ASSESSMENT OF LINKAGE AMONG SOCIO-ECONOMIC CENTERS (Criteria A, B and C)

Linkage between socio-economic centers was assessed in the following three cases:

i) Inter-Adjacent Amphoe Linkage (Criteria A)
ii) Inter-Changwat Linkage (Criteria B)
iii) Intra-Changwat Linkage (Criteria C)

The linkages between these centers were assessed from two aspects; accessibility on existing road links connecting these centers and inter-nodal gravity which indicates relative importance of socio-economic relationships between them.

5-2-1 Assessment of Accessibility

Level of accessibility on a linkage between nodes on existing road network can be theoretically specified primarily by comparing the travel time on the shortest existing route available with the travel time on an ideal road route between the nodes.

Hence, the following formula:

$$A = \frac{T_1}{T_2}$$

where, A : Accessibility

T_1 : Travel time on the existing road link

T_2 : Travel time on the ideal road link

The hypothetic ideal road was assumed to be paved road which connects two nodes in a straight line free from topographic and other constraints. In other words, the hypothetic ideal road link is a level tangent paved one.

The shortest available route to be compared with the corresponding ideal route was assumed as a level tangent road, in order to ensure the comparison on an equal basis.

The length of existing road links was measured separately for paved, laterite surfaced and earth surfaced sections by the use of the road map of DOH District Office. And, the travel time was estimated assuming different traveling speeds by surface condition; 80 km/hour on paved section, 50 km/hour on laterite section and 20 km/hour on earth sections. The length of ideal road links was calculated from coordinates value of each node on 1 to 250,000 scale topographic maps and the traveling speed was set simply to be 80 km/hour, since their sections were assumed to be all paved.

Accessibility was assessed by the following two sub-indicators:

i) Sub-indicator 1 : Linkages with travel time ratio of more than 1.5 were regarded as ones providing poor accessibility.

ii) Sub-indicator 2 : For the linkages defined as ones of poor accessibility by Sub-indicator 1, the differences of travel time were then checked, and those linkages with travel time differences of less than 0.3 hours were removed from further consideration, regarding that improvement of them would provide quite small effects.

Accessibility of each linkage were systematically calculated by filling the calculation form as given in Appendix 5-1.

5-2-2 Assessment of Inter-Nodal Gravity

Inter-nodal gravities were estimated in order to assess relative importance of socio-economic relationships between nodes.

Since importance of inter-nodal relationships was to be examined only in relative term in this study, the inter-nodal gravity could be specified by a simplified expression as follows:

$$G = \frac{P_i \cdot P_j}{L^2}$$

where, G : Inter-nodal gravity

P_i, P_j: Potentials of nodes i and j

L : Distance between nodes

The potentials of nodes, P_i or P_j, were represented by the area potentials of each Amphoe for Amphoe centers and by those of Amphoe Muang for Changwat centers which were estimated in Chapter 3, respectively.

For the distance between nodes, L in the formula, the length of the ideal road link calculated in 5-2-1 was applied.

In the analysis of the inter-nodal gravity, node pairs with higher gravity than the average value were regarded as those which have close relationships in terms of socio-economic activities.

5-2-3 Identification of Linkage to be Analized

The linkages between socio-economic centers to be further analized are identified as those screened by two major indicators defined in 5-2-1 and 5-2-2.

Numbers of the pertained linkages checked were 329 links for inter-adjacent Amphoe linkage, 36 links for inter-Changwat linkages and 127 links for intra-Changwat linkage. These linkages checked are shown in Drawings 4, 5 and 6, respectively.

Among them, however, the linkages which were visually judged to provide a good accessibility were rejected from the subject for further assessment. Thus, 189 links for inter-adjacent Amphoe, 18 links for inter-Changwat and 48 links for intra-Changwat were screened out as the subject links for quantification of the accessibility and inter-nodal gravity. They are shown, with value of quantified indicators in Appendixes 5-2, 5-3 and 5-4.

As a result of the assessment, 22 linkages in Inter-adjacent Amphoe case, 3 linkages in Inter-Changwat case and 1 linkage in intra-Changwat case were identified as the priority linkages to be analysed. They are shown under-lined in the said tables in the Appendixes and double-lined in the said Drawings.

5-3 ASSESSMENT OF INTRA-MARKET ZONE LINKAGE (Criterion D)

The linkages of those cases checked in 5-2 were chosen based on the basic concept that Changwat centers or Amphoe centers forming hub cities in the region should be connected each other in good conditions to facilitate better social mobility. In this section, the assessment of the linkages between hub cities having functions of assembly market of major agricultural products and Amphoe belonging to their zone of influence was made focusing particularly on economic connections.

Those linkages were assessed by two indicators; accessibility and commodity flow volume. The assessment of accessibility were carried out in the same way as applied in 5-2.

5-3-1 Assessment of Commodity Flow

To investigate the relative importance of linkages between assembly markets and their related Amphoe, the volumes of commodity flow on the specific links were assessed, putting stress mainly on agricultural products, as follows:

1) Estimation of Shipping Amount from Amphoe

For the estimation of the amount of surplus agricultural products to be shipped from each Amphoe to assembly markets, the amount of local consumption such as food, feed, processing materials and seeds preserved for local market or farmers was estimated as in the following manners.

Paddy; on the basis of population, number of farm households and the area cultivated annually in each Amphoe, the amount of food (white rice), processing material and preserved paddy and seeds available to the farmers was estimated with reference to the reports and information obtained in the field study.

Maize, Beans, Fruits and Vegetables; the amount is estimated using the information of reports[1/], export amounts at the national level, and several Changwat agricultural offices. Local consumption amounts for maize and beans were estimated at around 12% and 50-60% of the production amounts respectively. Fruits and vegetables were usually consumed nearby the production areas. In the large production centers, such as in and around Muang Chiang Mai and Lamphun, a certain amount of the surplus is shipped to terminal markets.

Raw Materials for Processing, such as Sugarcane, Tobacco leaves, Cassava roots and Seed cotton; Almost whole amounts or production are carried out to the factories by land transportation via local drying places, or directly from producing areas.

The shipping amount of main agricultural products in each Amphoe was estimated by deducting the amount of the local consumption estimated as in the above from the total amount of products in each Amphoe, which are given in Appendix 2-2 and Drawing 2.

2) Estimation of Flow Volume from Amphoe to Assembly Market

Generally, markets for agricultural products are classified into three categories, local assembly markets or grower's markets, major assembly markets or processing places, and terminal markets or Bangkok wholesale markets. The markets which exist in the Region are mainly local assembly markets and major assembly markets. However, cities of great consumption such as, Nakhon Sawan,

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1/ a) The marketing Costs and Margins of Farm Products
b) Estimate of Food Consumption in 1977-81, Agricultural Economic Division, Ministry of Agriculture & Cooperatives

Phitsanulok, Lampang, Chiang Mai and Chiang Rai are considered as terminal consuming markets for some food crops in the Region.

Local assembly markets are usually located in the places where crops are produced and where middlemen or local dealers purchase the products directly from the farmers. Products collected are then sent to major assembly markets nearby or closely related.

Major assembly markets are located mainly in urbanized Amphoes where the access to trunk highways, railways or waterways is available, and agricultural processing facilities exist. Information on the marketing of agricultural products was obtained from various sources, such as Industrial Economic and Planning Division, Division of Agricultural Economics, Amphoe Crop Production Reports prepared by Changwat Administrations, the State Railway of Thailand and the Inland Waterways Cargo Traffic Survey by the Harbor Department. According to them, there are around 50 places which can be called major assembly markets or which have processing factories for sugar, cassava, tobacco and cotton.

After agricultural products are gathered at major assembly markets, the products are shipped out to terminal markets, or to exporters, by either railways or by existing land or water systems. Processed agricultural goods such as sugar, cassava pellet or flour, tobacco, ginned cotton are sent directly from the factories to terminal markets, or to other refinery and textile factories. Commodity flows to be considered in this study are limited to the flows from local markets to major assembly markets or major processing places, as transportation of the products by truck to terminal markets are through on the artery paved highways which are already improved.

Studying the zones of influence of each major assembling center, linkages between assembly markets and the related Amphoe were specified.

On the basis of the estimated shipping amount of main agricultural products from each Amphoe, flow volumes were assigned to each specified link by crop and then summed up. Thus estimated commodity flow by O/D pair are shown in Appendixes 5-5 and 5-6. In the estimation of the flow volumes, major crops were limited to rice, maize, beans, sugar cane, cassava and tobacco leaves, as the handling volumes of the other crops were not so significant.

3) Assessment of Commodity Flow

Among those of the checked links, the linkages with the commodity volumes of more than average were regarded as the linkages which have economically important relationships.

5-3-2 Identification of Linkages to be Analized

The intra-market zone linkages to be further analysed were identified as those screened by two indicators, satisfying the conditions of poor accessibility and above average commodity flow volume, as described previously. Number of the linkages checked was 256 links as shown in O/D table in Appendix 5-5 and Drawing 7. However, the linkages which can be obviously judged to provide good accessibility were rejected from the further assessment. Thus, the linkages assessed by the quantified indicators became to 61 links. They are shown, with their quantified indicators, in Appendix 5-7. Finally as the result of assessment, 8 linkages were identified as those to be further analysed. They are shown putting underlines in the said tables in Appendix 5-7 and double-lines in the said Drawing 7.

5-4 ASSESSMENT OF AMPHOE TO ARTERY HIGHWAY LINKAGE
(Criterion E)

From the viewpoint of forming better road networks to facilitate better social mobility, it is required, at least, that every Amphoe should be connected with artery highway by paved road. Furthermore, even in case that a connection by a paved road is available, the connection is desirable to be in better condition in terms of direction and distance.

On the basis of the above-mentioned concept, conditions of the existing road networks connecting Amphoe with artery paved highways were checked mainly referring to the road maps prepared by the DOH District Offices.

As the results, 8 links were identified for further analysis as listed in Appendix 5-8.

5-5 ASSESSMENT OF LATERAL-TYPE LINKAGE
(Criterion F)

In the region, especially in its central part, trunk highway networks in a North-South direction will mostly complete upon implementation of the ongoing Route 11 and 1142. On the other hand, lateral-type-roads which traverse linking North-South highways are not well developed in terms of density and conditions of roads as well. Major factors which have caused the insufficient development of East-West highways may include topographic constraints and less benefits attributable comparing with routes in a North-South direction.

It is judged, however, that attention should be paid more to the construction of East-West highways in future plans, viewing that very few routes in a North-South direction remain for further development. In general conception, lateral-type-highways in the Northern Region are desired to be planned at around 50 km interval. Priority is, however, given to the routes which satisfy following conditions:

- routes included in a DOH's future plan but not yet committed

- routes which enable to utilize existing roads, even small tracks.

From the above-mentioned consideration, 3 links of lateral-type-linkage to be analysed were identified as listed in Appendix 5-9.

5-6 ASSESSMENT OF DOH UNPAVED ROAD (Criterion G)

In order to identify the road development requirement at rural level, all existing unpaved roads under DOH except those committed for improvement were examined. For 118 links of 3,820 km in total, population and cultivable land influenced by the roads were measured as shown in a table of Appendix 5-10 and in Drawings 8 and 9.

Links worthy of further analysis were selected from those who have higher values than averages both in population and cultivable land per kilometer of subject roads as shown in Appendix 5-11.

As the result, 13 links were identified as the subjects of further analysis. These links are shown marking a circle on link numbers in the said table of Appendix 5-10.

5-7 ASSESSMENT OF FEEDER ROAD REQUIREMENT (Criterion H)

To determine the priority areas which require feeder roads, a concept to be called "road requirement index" was introduced.

One of the study objectives includes identification of feeder roads requirement in the central six Changwat, in particular, Nakhon Sawan, Phichit, Phitsanulok, Uttaradit, Phrae and

Lampang related to the ongoing Route 11 and Route 1142. To make the area subject to this study a geographic entity which is easy to work with, two additional Changwats, Kamphaeng Phet and Sukhothai were included in this study.

5-7-1 Road Requirement Index

Procedure of estimation of the road requirement index is shown in Figure 5-2.

The road requirement index is defined as a product of the mesh potential and distance to the nearest existing road. A mesh which has a high index is assessed as the one which requires more feeder roads. As a result, each mesh was classified into four ranks depending on its numerical index.

Calculated results of the road requirement index are shown in Drawing 10.

5-7-2 Identification of Feeder Road Requirement Areas

In section 5-7-1, the road requirement index was defined, and the value of the index was given to each mesh.

Based on the calculated result, an area which was composed of more than 10 meshes with more than a 1,000 index value was identified as a feeder road requirement area. However, meshes located within 5 km from the nearest existing road were not counted, as these areas were judged to have satisfactory road systems.

As a result, 33 feeder road requirement areas were derived as the subject for further analysis.

5-8 IDENTIFICATION OF PROPOSED ROUTE

In the Step I Study described in the previous sections, priority links were identified on a theoretical basis from various viewpoints of criteria for further analysis in the Step II Study.

In the Step II, the routes corresponding to each priority link were examined and planned on a practical basis, and finally the proposed routes were listed up separating by implimentation phase.

The proposed routes were planned on 1 to 250,000 scale topographic maps. In the planning, topographic conditions, location of villages, utilizations of existing roads, connections with other existing road networks, etc., were taken fully into consideration.

As the identification in the Step I were carried out individually by each planning criteria, duplication were remained among the selected linkage or links. They were, therefore, arranged to eliminate duplications in this step of the route planning on topographic maps.

The routes were also planned in consideration of combination of road functions derived from different criteria. For example, in case that the road requirement areas are located nearby a link to be improved its accessibility, the route was so designed that it would traverse the areas as much as possible sacrificing, to certain extent, the travel time savings, despite of the original aim at improving the accessibility. The feeder roads were planned so as to pass through the heart of the road requirement areas and to connect it with a adjacent existing highway. After the route planning on the topographic maps, outcome of the planning were refined by the results of field reconnaissances and discussion with DOH. Some of the routes were cancelled in this stage, mainly due to the following reasons:

- Roads mainly of other agencies exist in good condition along or nearby the identified routes, inspite they are not found in the beginning stage of data collection.

- Some routes were decided recently to be committed for improvement.

Finally, 44 proposed routes, 1,187.8 km in total, were listed up, as shown in Drawing 11. The following table shows comparison between numbers of links selected in the Step I and these of routes proposed finally.

Comparison between Number of Links Selected in the Step I and Step II

	Planning Criteria	Number of Links Selected	
		Step I	Step II
A	Inter-Adjacent Amphoe Linkage	22	9
B	Inter-Changwat Linkage	3	1
C	Intra-Changwat Linkage	1	0
D	Intra-Market Zone Linkage	8	1
E	Amphoe-Artery Highway Linkage	8	8
F	Lateral-Type Linkage	3	3
G	DOH Unpaved Road	13	13
H	Feeder Road Requirement	33 1/	9
	Total:		44

Note: 1/ not links but numbers of the road requirements area

The proposed route of 44 links were presented to DOH for comment and separation of the list into short/medium term program and long term program.

As a result, 31 links of 862.1 km in total were selected as routes for short/medium term, for which further evaluation at pre-feasibility level is to be proceeded with. The remaining

13 links of 325.7 km in total were reserved for long term program. The final list of proposed routes, both for short/medium range and long range, are given in Table 5-1.

Figure 5-1 PROCESS OF ROUTE IDENTIFICATION

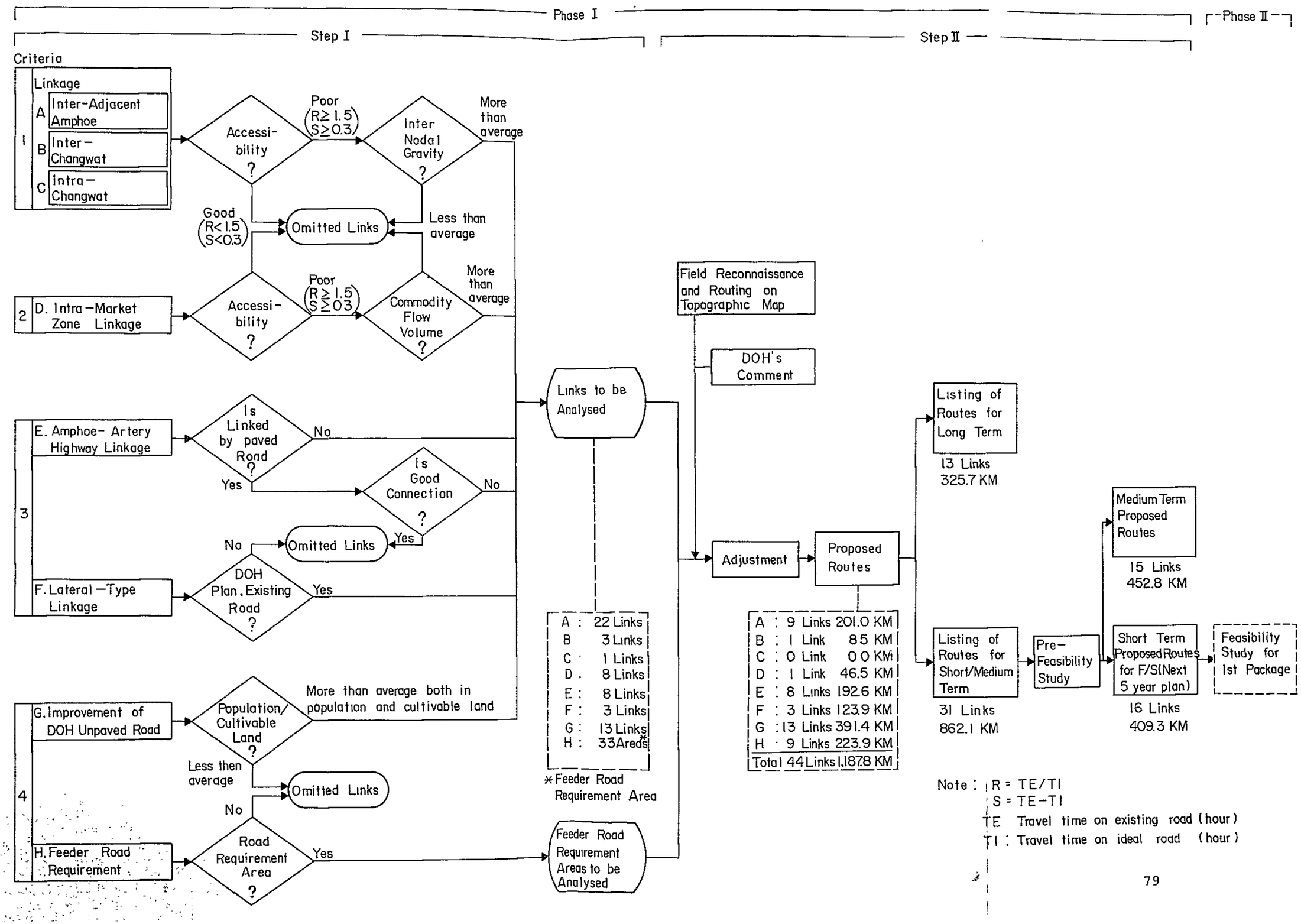
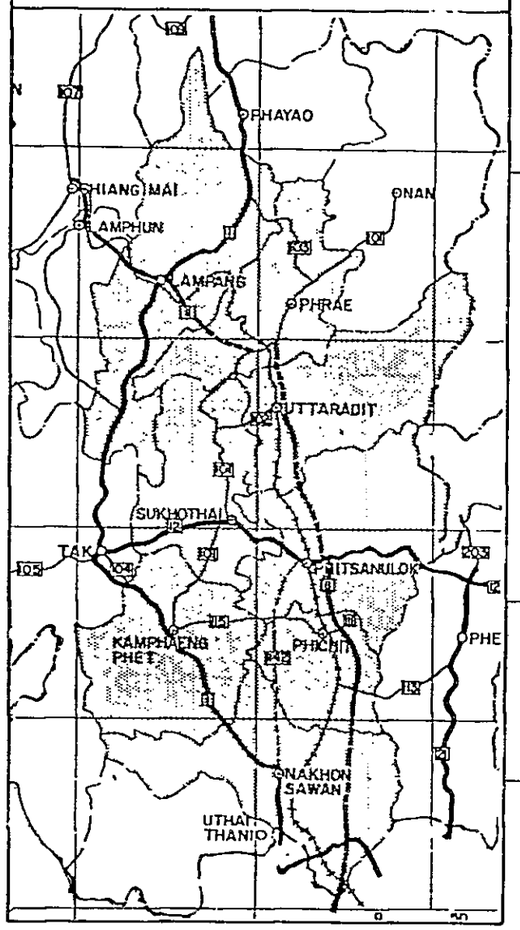


Figure 5-2 ESTIMATION PROCEDURE OF ROAD REQUIREMENT INDEX

OBJECTIVE AREA



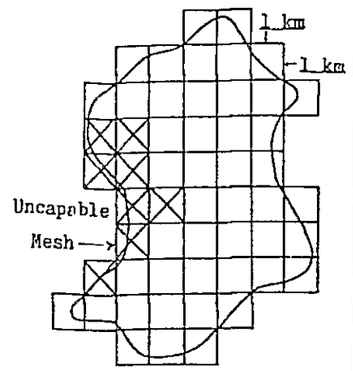
POTENTIAL VALUE IN AMPHOE

TAMBON POPULATION
(NSO Statistics in 1979)

Capability Map

Land Use Map

TO PREPARE MESH MAP



TO SET ROAD NETWORKS

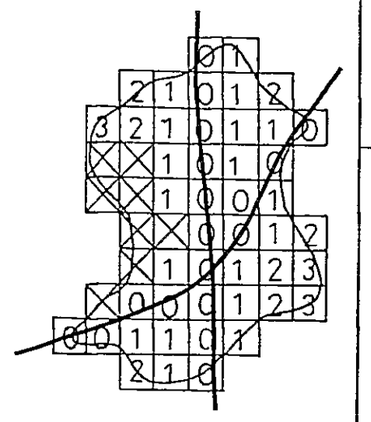
Exsisting: DOH (all)
ARD (all)
RID (all)

Planned: Committed by International lending agencies and to be implemented under the next five-year plan

TO ESTIMATE POTENTIAL IN EACH MESH

AMPHOE POTENTIAL
Tambon population rate
TAMBON POTENTIAL
Number of Mesh in Tambon
MESH POTENTIAL

TO COUNT DISTANCE FROM NEARBY ROAD TO MESH



TO CALCULATE "ROAD REQUIREMENT INDEX"

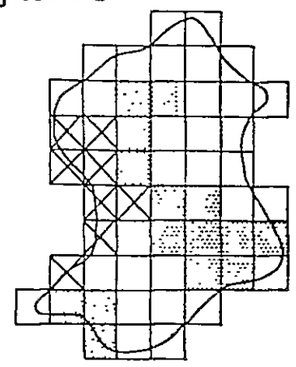
$Wi = pi \cdot di$

where,

Wi: Road Requirement Index
pi: potential at Mesh-i
di: distance from road to Mesh-i

IDENTIFICATION OF THE AREA OF ROAD REQUIREMENT

Grade 1



Grade	Value of Index
1	More than 1,000
2	500 - 1,000
3	250 - 500
4	less than 250

Table 5-1 LIST OF PROPOSED ROUTES

(1) SHORT/MEDIUM TERM PLAN

Study Route No.	Proposed Road Route				Length (km)			Method Symbol
	Changwat	Route	Origin	Destination	Improvement	New Construction	Total	
1	Nakhon Sawan	R.3330/ PWD	B. Sam Yaek Samrong Chai (J.R.1)	A. Phai Sali (J.R.3004)	33.3		33.3	G
2	"	R.1145	B. Hua Thanon Nua (J.R.3004)	B. Tak Fa (J.R.1)	27.9		27.9	G
3	"	R.3329/ R.1145	B. Sam Yaek (J.R.1)	B. Hua Thanon Nua (J.R.3004)	46.5		46.5	D
4	"	R.1119	A. Nong Bua	B. Phanom Rok	32.0		32.0	G
5	"	Rural	A. Kao Lieo	B. Koei Chai Nua (J.R.1118)	8.8	13.7	22.5	A
6	Kamphaeng Phet/ Nakhon Sawan	Rural	A. Khanuworalaksa Buri (J.R.1074)	B. Map Yang (J.R.1142)	42.6		42.6	E
7	Phetchabun	ARD/ MDU	A. Chon Daen (J.R.113)	A. Nong Phai (J.R.21)	39.3	2.4	41.7	A
8	Kamphaeng Phet	Rural	B. Thung Ma Ha Chai (J.R.115)	B. Nong Takhian	46.0	3.5	49.5	H
9	"	Rural	B. Thung Ma Ha Chai (J.R.115)	B. Tha Makhua (J.R.1084)	29.5	3.0	32.5	A
10	Phichit	PWD/ ARD/ R.9045/ R.1207	B. Tha Khoi (J.R.1068)	A. Taphan Hin (J.R.1118)	12.6		12.6	A
11	"				16.1		16.1	G
12	"	Rural	B. Wang Chik (J.R.1068)	B. Pa Daeng (J.R.1142)	14.4	1.0	15.4	H
13	"	PWD/ Rural	A. Wang Sai Phum (J.R.11)	B. Nong Phayom (J.R.113)	13.0	11.0	24.0	A
14	Phichit/ Phetchabun	Rural/ R.1119/ R.1205	B. Nong Khanak (J.R.11)	B. Wang Pong	22.4	2.0	24.4	G
15	Phichit/ Phitsanulok	R.1221/ ARD	B. Wang Tham (R.1221)	B. Tha Makham (R.J.1114)	7.5	1.0	8.5	B
16	Kamphaeng Phet	PWD	B. Wang Phikun (J.R.115)	A. Lan Krabu (J.R.1065)	13.1		13.1	A
17	Phitsanulok	R.9034/ ARD	A. Bang Rakam (J.R.1065)	B. Nong Bua (J.R.1142)	14.9		14.9	G

Table 5-1 LIST OF PROPOSED ROUTES (Continued)

(1) SHORT/MEDIUM TERM PLAN (Cont'd)

Study Route No.	Proposed Road Route				Length (km)			Method Symbol
	Changwat	Route	Origin	Destination	Improvement	New Construction	Total	
18	Sukhothai	ARD	A. Khili Mat (J.R.101)	B. Nong Tum (J.R.9117)	13.5	2.5	16.0	H
19	Phitsanulok	Coop.	A. Phrom Phiram	B. Nong Makhang (J.R.11)	13.3	1.3	14.6	A
20	"	R.1220	A. Wat Bot	B. Na Kham	15.0		15.0	G
21	Uttaradit	R.9053/ ARD	B. Na Isang (J.R.11)	A. Phichai	13.7	4.7	18.4	E
22	Uttaradit/ Sukhothai	ARD	A. Phichai	A. Si Nakhon	11.5	1.7	13.2	E
23	Sukhothai	R.1113	B. Muang Kao (J.R.12)	B. Muang Kao (J.R.1201)	37.2	14.1	51.3	G
24	Sukhothai/ Lampang	R.1048	A. Thung Saliam (R.1048)	B. Don Chai (J.R.1)	51.7	5.0	56.7	G
25	Phrae/ Lampang	R.1124	A. Wang Chin	B. Don Chai (J.R.1)	50.0	2.0	52.0	F
26	Lampang	R.1184	A. Li (J.R.106)	B. Puang (R.1235)	18.5		18.5	F
27	"	R.1219	B. Mae Thoei (J.R.106)	A. Thung Hua Chang (J.R.1184)	16.0	0.5	16.5	E
28	Nan	R.9061	A. Na Noi (R.1026)	A. Na Muen	20.0		20.0	E
29	Chiang-Rai	R.1207	B. Rong Sua Ten (J.R.110)	B. Huai Khom	13.4		13.4	G
30	"	R.1174	B. Thung Ngiu (J.R.1020)	B. Chomphu (J.R.1020)	42.0	1.5	43.5	G
31	"	R.1098	B. Kiu Phrao (J.R.1016)	B. Kaen Tai (J.R.1174)	54.5	1.0	55.5	G
				Sub-total	790.2	71.9	862.1	

Table 5-1 LIST OF PROPOSED ROUTES (Continued)

(2) LONG TERM PLAN

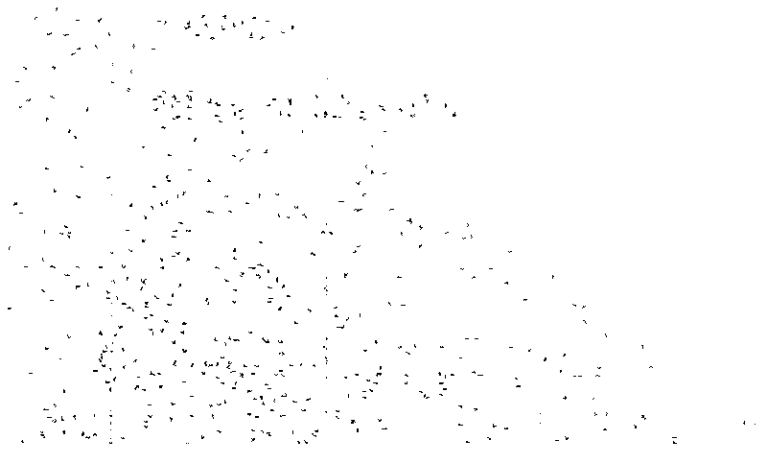
Study Route No.	Proposed Road Route				Length (km)			Method Symbol
	Changwat	Route	Origin	Destination	Improvement	New Construction	Total	
32	Nakhon Sawan/ Phetchabun	Gypsum Road	A. Nong Bua	B. Wang Katha (J.R.1069)	27.0		27.0	H
33	Nakhon Sawan/ Phichit		B. Huai War Tai (J.R.1119)	B. Wang Khon (J.R.1069)		25.0	25.0	A
34	Tak/Kamphaeng Phet	R.1117	A. Umpang	B. Khun Nam Yen (R.1117)	34.4		34.4	E
35	Phichit		B. Thap Khlo (J.R.113)	B. Khok Sa		10.0	10.0	H
36	Kamphaeng Phet/ Phichit		B. Thung Sai	B. Wang Samrong		50.0	50.0	H
37	Phichit/ Phetchabun	R.1191	B. Nong Ramang (J.R.1205)	B. Wang Hin	7.4		7.4	G
38	Phitsanulok	Rural	B. Plak Reat (J.R.9034)	B. Bung Kok (J.R.1065)	5.0		5.0	H
39	"	Rural	B. Rai (J.R.1063)	B. Noen Phrai (J.R.11)	15.0		15.0	A
40	"	Rural	B. Tha Kham (J.R.12)	B. Na Phan	23.0		23.0	H
41	Sukhothai/Phitsanulok		B. Don Manuang (J.R.12)	B. Nong Phai		28.0	28.0	H
42	Uttaradit	R.1214	A. Tron	B. Nam Auang (J.R.11)	12.5		12.5	E
43	"	R.1047	A. Ban Khok	A. Fak Tha	35.0		35.0	E
44	Chiang Mai/ Chiang Rai	J.1150	A. Phrao	A. Wiang Pa Pao (J.R.1019)	53.4		53.4	F
				Sub-total	212.7	113.0	325.7	
				Total	1,002.9	184.9	1,187.8	

Total by Each Criteria

A : 9 links - 201.0 km
B : 1 link - 8.5 km
C : 0 link - 0.0 km
D : 1 link - 46.5 km
E : 8 links - 192.6 km
F : 3 links - 123.9 km
G : 13 links - 391.4 km
H : 9 links - 223.9 km

CHAPTER 6

EVALUATION OF ROUTES



CHAPTER 6

EVALUATION OF ROUTES

6-1 PROCESS OF EVALUATION

Economic evaluation, at a pre-feasibility level, is to be made on routes selected for short/medium term projects, 31 routes shown in Table 5-1, in order to present a priority ranking of the routes. It should be noted, viewing the immediate aim of this evaluation, that internal rates of return (IRR) to be calculated hereby do not show any final indicators for the project justification but provide a kind of yardstick for relative examination among projects.

The process of the evaluation on this stage is illustrated in Figure 6-1. All of the elements of project costs and benefits, necessary for calculation of IRR, were estimated as discussed in the following sections.

Figure 6-1 FLOW OF EVALUATION PROCESS

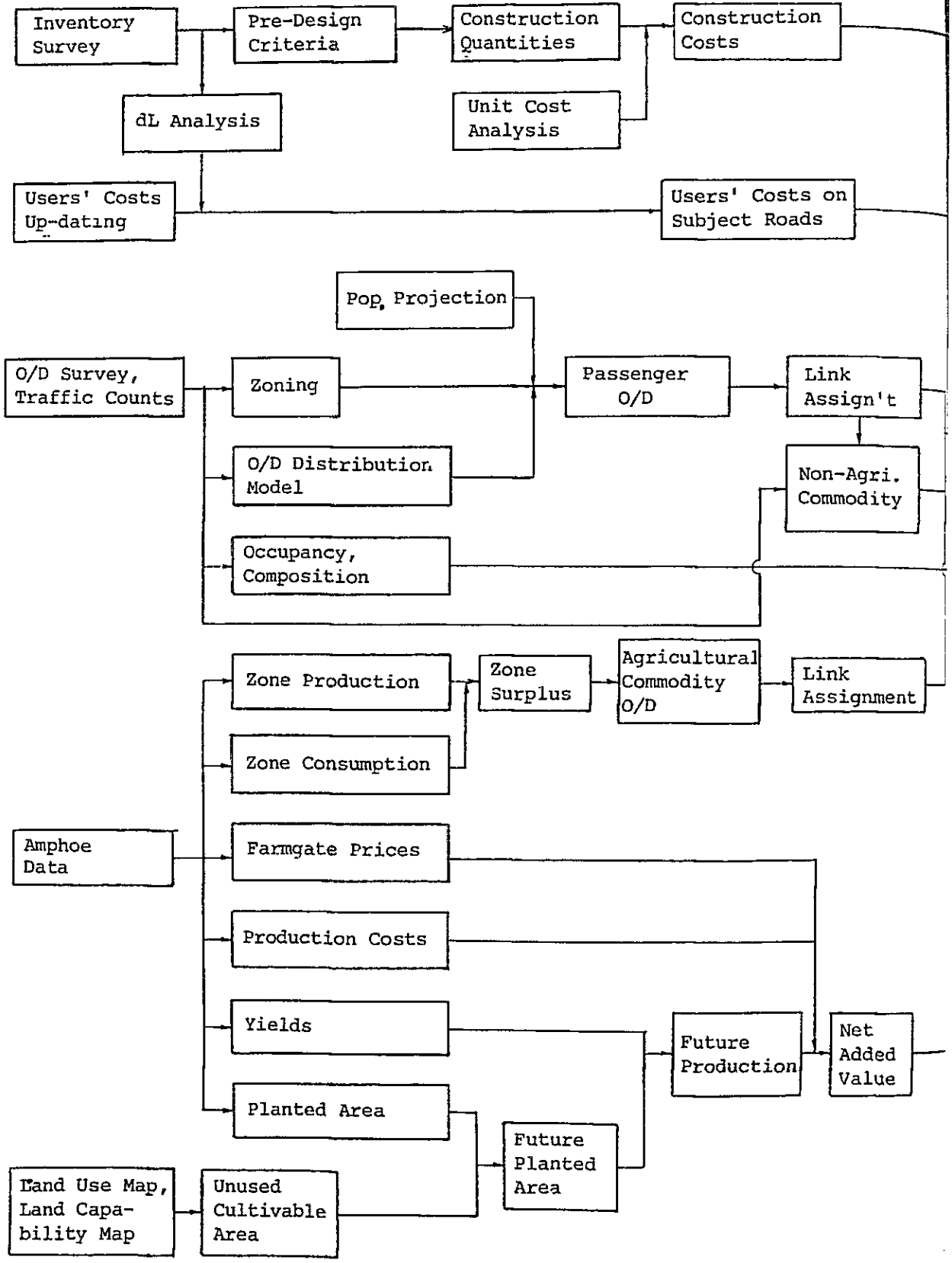
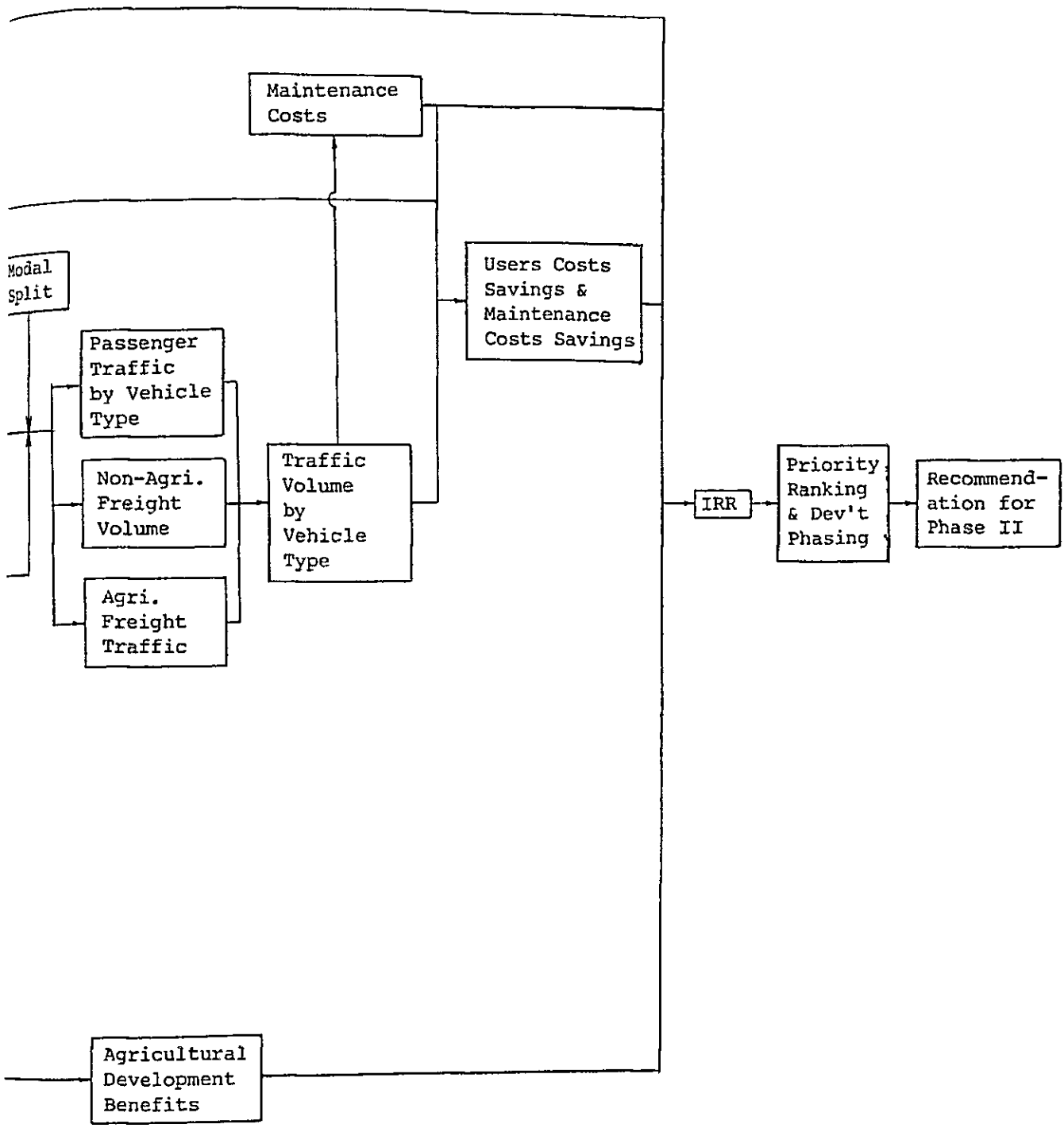


Figure 6-1


Maintenance Costs
Modal Split
Users Costs Savings & Maintenance Costs Savings
Passenger Traffic by Vehicle Type
Non-Agri. Freight Volume
Agri. Freight Traffic
Traffic Volume by Vehicle Type
IRR
Priority Ranking & Dev't Phasing
Recommend-ation for Phase II
Agricultural Development Benefits

6-2 STUDY ROUTES

6-2-1 Inventory Survey

To obtain information on the present conditions of the identified 31 routes, the inventory survey was conducted at a pre-feasibility study level of detail. The total length of routes actually surveyed was about 840 km.

The major items of inventory survey comprised the road length and width, alignment, surface type, embankment height/cut depth, location and condition of bridges, terrain and land use along the routes, and the past records of flood.

The number of houses of major villages along the routes was also inquired. The information on flooding in the past was obtained from local people.

The results of the road inventory survey are given in Appendix 6-2-1.

6-2-2 Characteristics of Routes

In Table 6-1, the characters of each proposed route are summarized from the results of the road inventory surveys.

The routes surveyed locate in 12 Changwat in the Northern Region, and more than half of them belong to DOH, whereas the remainings are under the responsibilities of other agencies such as ARD, PWD and local government.

The routes in the southern part of the Region pass mostly the flat lowland area of paddy fields and partly the undulating upland area of maize, sugarcane, cotton and beans. On the other hand, the routes located in the middle and northern parts of the Region sometimes run the rolling or mountainous terrains. In those rolling and mountainous terrains, the roadside areas have been remained uncultivated as forest and bush.

The surface types of the roads are mostly of laterite surfaced. The earth roads share about 10 percent of whole length of the roads surveyed, and asphaltic concrete and surface treatment sections are about 20 km in total. The surface conditions range from good to bad conditions irrespective of the surface type.

While the DOH, ARD and PWD roads fall under the category of F5 or F6 Class of DOH Design Standard in road width and alignments, the rural roads belong to quite low class road with narrow width and fair or bad alignment and surface conditions.

Most of the roads surveyed are embankment type, the height of which is as low as 0 - 1.5 meters. Therefore the roads in lowland area have been suffered flooding. In rolling and mountainous terrain, cut type roads are found, the cutting depth of which is less than one meter.

There are 193 bridges in the surveyed routes, consisting of 166 timber bridges and 27 permanent concrete bridges. The timber bridges with total length of 2,080 meters are mostly one lane width. They are judged, from visual inspection, to have not enough structural strength to the design load of DOH. The concrete bridges, 887 meters long in total, satisfy the requirement of carriageway width of F4 Class of DOH Design Standard except for six narrow bridges in four routes.

Table 6-1 SUMMARY OF ROAD INVENTORY

Series No.	Changwat	Route No.	Route Termini		Length (Km)	Terrain	Width (m)	
			Origin	Destination			Formation	Carriageway
1.	Nakhon Sawan	R.3330/ PWD	Ban Sam Yaek Samrong Chai	Amphoe Phai Sali	33.3	Rolling (10 km) Flat (23.3 km)	7.5 ∿10.0	5.0 ∿6.5
2.	Nakhon Sawan	R.1145	Ban Hua Thanon Nua	Ban Tak Fa	27.9	Flat	8.0 ∿9.0	6.0 ∿8.0
3.	Nakhon Sawan	R.3329/ R.1145	Ban Sam Yaek	Ban Nong Luang	38.8	Flat	7.0 ∿9.0	4.5 ∿8.0
4.	Nakhon Sawan	R.1119	Amphoe Nong Bua	Ban Phanom Rok	32.0	Flat	7.5 ∿9.5	5.0 ∿7.0
5.	Nakhon Sawan	Rural Road	Amphoe Kao Lieo	Ban Klong Yang	14.6	Flat	5.0 ∿7.0	3.5 ∿5.0
			Ban Sam Yaek Keiy Chai	Ban Keiy Chai Nua	0.8	Flat	8.0	3.5
6.	Kamphaeng Phet/ Nakhon Sawan	Rural Road	Amphoe Khanu-woralaksa Buri	Amphoe Kao Lieo	37.6	Flat	4.5 ∿7.5	3.0 ∿5.5
7.	Phetchabun	ARD/ MDU	Amphoe Chon Daen	Amphoe Nong Phai	41.7	Rolling	4.5 ∿7.5	2.7 ∿5.5
8.	Kamphaeng Phet	Rural Road	Ban Thung Sai	Ban Kho Plono	28.9	Flat (14 km) Rolling (14.9 km)	3.0 ~6.5	2.5 ∿3.5

Roadway Condition						Bridge			Flooding
Surface		Aligiment		Embankment/ Cut (m)		Nos.	Width (m) & Accumulative length (m)	Land Use	Overflow H. (cm) & Section (Km)
Type	Condition	Horizontal	Vertical	Emb.H.	Cut D.				
Laterite	Good	Good	Good to Fair	0.3 ∿1.2	0.4 ∿0.8	6(C)	7.0 x 107.0	Paddy Maize Cotton	No Flooding
Laterite	Good	Good	Good to Fair	0.5 ∿1.0	-	-	-	Paddy Cotton Cassava Maize	No Flooding
Laterite	Good to Fair	Good	Good	0.5 ∿1.2	-	4(C)	7.0 x 59.5	Paddy Maize Sugarcane Cotton Cassava	No Flooding
Laterite Surface Treatment (2.3 Km)	Good	Good	Good	0.4 ∿1.5	-	3(C)	8.0 x 56.5	Paddy	No Flooding
Laterite Earth (4.6 km)	Fair To Bad	Good	Good	0.5 ∿1.0	-	-	-	Paddy Sugarcane	No Flooding
Laterite	Good	Good	Good	0.7	-	-	-		No Flooding
Laterite Earth (16 km)	Fair to Bad	Good to Fair	Good to Fair	0 ∿0.8	-	-	-	Paddy Sugarcane	No Flooding
Laterite	Fair to Bad	Good to Fair	Fair to Bad	0 ∿1.0	-	16(T)	4.2 x 287.5	Maize	No Flooding
Earth Laterite (10.6 km)	Fair to Bad	Good to Bad	Fair	0 ∿1.5	-	16(T)	2.5 i 4.5 x 200.5	Paddy Bean Cassava	No Flooding

Table 6-1 SUMMARY OF ROAD INVENTORY (Continued)

Series No.	Changwat	Route No.	Route Termini		Length (Km)	Terrain	Width (m)	
			Origin	Destination			Formation	Carriageway
9.	Kamphaeng Phet	Rural Road	Ban Thung Ma Ha Chai	Ping River	35.1	Flat	4.5 ∿7.0	3.8 ∿5.5
10. /11.	Phichit	R.9045/ R.1207/ PWD/ARD	Route 1068	Amphoe Taphan Hin	28.7	Flat	6.0 ∿9.0	3.8 ∿6.0
12.	Phichit	Rural Road	Ban Wang Chik	Ban Pa Daeng	15.4	Flat	3.0 ∿5.0	2.5 ∿3.0
13.	Phichit	PWD/ Rural Road	Amphoe Wang Sai Phun	Ban Nong Phayom	26.0	Flat	3.5 ∿9.0	2.5 ∿6.0
14.	Phichit/ Phetchabun	R.1191/ R.1205/ Rural Road	Ban Nong Khanak	Ban Wang Pong	25.2	Flat Rolling (3.3km)	4.5 ∿8.5	3.0 ∿5.5
15.	Phichit/ Phitsanulok	R.1221/ ARD	Ban Wang Tham	Ban Tha Makham	8.7	Flat	6.0 ∿9.4	3.0 ∿7.0
16.	Kamphaeng Phet	PWD	Ban Wang Phikun	Amphoe Lan Krabu	13.1	Flat	8.0 ∿11.0	5.5 ∿7.0
17.	Phitsanulok	R.9034/ ARD	Amphoe Bang Rakam	Ban Plak Reat	14.9	Flat	5.6 ∿9.0	3.0 ∿5.5

Roadway Condition						Bridge			Flooding
Surface		Alignment		Embankment/ Cut (m)		Nos.	Width (m) & Accumulative length (m)	Land Use	Overflow H. (cm) & Section (Km)
Type	Condition	Horizontal	Vertical	Emb.H.	Cut D.				
Laterite Earth (10.0 km) S.T (1.2 km)	Fair to Bad	Good to Bad	Good	0 ∿1.0	-	4(T)	4.0 ∫ 6.0 x 27.0	Sugar-cane Paddy	40 x 1.5 (3 places)
Laterite	Good to Fair	Good	Good	0.5 ∿3.0	-	-	-	Maize Paddy	50 x 1.0 (4 places)
Earth Laterite (4.8 km)	Fair to Bad	Fair	Fair	0.5 ∫ 1.0	-	-	-	Paddy	50 x 1.5 (2 places)
Laterite Earth (4 km)	Good to Bad	Good to Bad	Good to Fair	0.5 ∫ 1.0	-	7(T)	3.5 x 22.5	Paddy	No Flooding
Laterite	Fair to Bad	Fair	Fair to Bad	0 ∿1.0	-	3(T)	2.5 ∫ 3.5 x 31.5	Paddy	No Flooding
Laterite A.C. (2 km)	Fair to Bad	Good	Good	0.5	-	-	-	Paddy	No Flooding
Laterite	Good to Fair	Good to Fair	Good	0.5 ∿1.2	1.0	3(C)	7.0 x 60.0	paddy	No Flooding
Laterite S.T. (0.7 km)	Fair	Good	Good	0 ∿0.5	-	-	—	Paddy	No Flooding

Table 6-1 SUMMARY OF ROAD INVENTORY (Continued)

Series No.	Changwat	Route No.	Route Termini		Length (Km)	Terrain	Width (m)	
			Origin	Destination			Formation	Carriageway
18.	Sukhothai	ARD	Amphoe Khiri Mat	Ban Nong Tum	16.0	Flat	6.4 ∿10.8	4.1 ∿7.2
19.	Phitsanulok	Cooperative Road	Amphoe Phrom Phiram	Ban Nong Makhang	13.5	Flat	6.8 ∿13.0	4.6 ∿8.7
20.	Phitsanulok	R.1220	Amphoe Wat Bot	Ban Na Kham	15.0	Flat	5.7 ∿10.0	3.9 ∿7.0
21.	Uttaradit	R.9053/ ARD	Route 11	Amphoe Phichai	22.7	Flat	7.6 ∿9.0	4.5 ∿5.6
22.	Uttaradit/ Sukhothai	ARD	Amphoe Phichai	Amphoe Si Nakhon	15.9	Flat	6.8 ∿10.0	5.0 ∿6.2
23.	Sukhothai	R.1113	Ban Muang Kao (R. 12)	Ban Muang Kao (R. 1201)	51.3	Flat	3.0 ∿9.0	2.0 ∿5.6
24.	Sukhothai/ Lampang	R.1048	Amphoe Thung Saliam	Ban Don Chai	56.7	Rolling Flat (6.6km) Mountainous (8.6km)	2.5 ∿6.3	2.3 ∿4.2

Roadway Condition						Bridge		Land Use	Flooding
Surface		Alignment		Embankment/ Cut (m)		Nos.	Width (m) & Accumulative length (m)		Overflow H. (cm) & Section (Km)
Type	Condition	Horizontal	Vertical	Emb.H.	Cut D.				
Laterite A.C. (1.4 km)	Good to Fair	Good to Bad	Good	0 ~2.0	-	1(C) 2(T)	5.0 x 10.0 4.0 / 6.4 x 27.5	Paddy	50 x 1.5 (3 places)
Laterite Earth (3.5 km) S.T (0.5 km)	Good to Bad	Good to Bad	Good	0.5 ~3.0	-	1(T)	6.5 x 36.3	Paddy	150 x 8.0 (1 place)
Laterite	Fair to Bad	Fair	Fair	0 ~2.0	-	2(T)	4.0x13.0	Paddy Maize Bean	50 x 5.0 (10 places)
Laterite	Good	Good	Good	0.5 ~1.0	-	1(C)	3.5x33.0	Paddy Maize Bean	50 x 1.5 (3 places)
Laterite S.T. (3.4 km)	Good to Fair	Good	Good	0.7 ~1.0	-	2(C)	7.0 / 8.0 x 242.0	Paddy Sugar-cane	No Flooding
Laterite Earth (12 km) A.C. (1.0 km)	Fair to Bad	Good	Good	0 ~1.5	-	10(T) 1(C)	2.5 / 5.0 x 90.2 5.0 x 3.0	Paddy Maize Sesame Cotton	50 x 12.0 (many places)
Laterite	Fair to Bad	Fair to Bad	Fair to Bad	0 ~1.0	-	15(T)	2.0 / 4.5 x 164.2	Paddy Forest Bush	50 x 1.2 (2 places)

Table 6-1 SUMMARY OF ROAD INVENTORY (Continued)

Series No.	Changwat	Route No.	Route Termini		Length (Km)	Terrain	Width (m)	
			Origin	Destination			Formation	Carriageway
25.	Phrae/ Lampang	R.1124	Amphoe Wang Chin	Ban Don Chai	52.5	Rolling Flat (4.0km) Mountainous (3.0km)	3.8 ∿6.0	2.5 ∿4.0
26.	Lamphun	R.1184	Amphoe Li	Ban Puang	18.5	Rolling Flat (5.5 km)	5.0 ∿7.4	3.8 ∿4.8
27.	Lamphun	R.1219	Ban Mae Thoei	Amphoe Thung Hua Chang	17.7	Rolling Flat (3.6km)	4.0 ∿7.5	2.7 ∿5.0
28.	Nan	R.9061	Amphoe Na Noi	Amphoe Na Muen	20.0	Flat Rolling (8.1 km)	5.0 ∿7.0	4.5 ∿5.5
29.	Chiang Rai	R.1207	Ban Rong Sua Ten	Ban Huai Khom	13.4	Rolling	5.8 ∿7.0	4.2 ∿4.5
30.	Chiang Rai	R.1174	Ban Thung Ngiu	Ban Chomphu	47.6	Flat	5.5 ∿8.2	4.0 ∿6.0
31.	Chiang Rai	R.1098	Ban Kiu Phrao	Ban Kaen Tai	56.0	Flat Rolling (18.2km)	3.5 ∿8.0	2.5 ∿6.0

Roadway Condition						Bridge		Land Use	Flooding
Surface		Alignment		Embankment/ Cut (m)		Nos.	Width (m) & Accumulative length (m)		Overflow H. (cm) & Section (Km)
Type	Condition	Horizontal	Vertical	Emb. H.	Cut D.				
Laterite S.T. (3.5 km)	Fair	Fair to Bad	Fair to Bad	0 ~1.0	-	41(T)	3.7 / 5.5 x 417.6	Paddy Forest Bush	50 x 0.13 (3 places)
Laterite	Fair to Bad	Fair to Bad	Fair to Bad	0	0.5	6(T)	3.0 / 4.0 x 117.5	Paddy Forest Bush	50 x 1.0 (1 place)
Laterite S.T. (1.1 km)	Fair to Bad	Fair to Bad	Fair to Bad	0 ~0.5	0.5 ~1.0	6(T)	3.3 / 4.0 x 116.7	Bush Forest	No Flooding
Laterite S.T. (1.6 km)	Fair to Bad	Fair	Fair to Bad	0 ~1.0	0.5	4(T)	4.0 / 5.5 x 88.0	Paddy Bush	No Flooding
						5(C)	3.5 / 7.0 x 210.0		
Laterite	Fair to Bad	Fair	Fair	0 ~0.5	-	3(T)	3.6 / 4.3 x 35.7	Paddy	50 x 0.2 (1 place)
Laterite S.T. (3.3 km)	Good to Bad	Fair	Fair	0 ~1.0	-	11(T)	4.0 / 4.5 x 194.0	Paddy	50 x 5.0 (1 place)
						1(C)	7.2 x 106.0		
Laterite Earth (7.6 km)	Fair to Bad	Fair to Bad	Good to Bad	0 ~1.0	0.5 ~1.0	19(T)	3.0 / 4.2 x 208.8	Paddy Forest Bush	No Flooding

6-3 TRAFFIC SURVEY AND FORECAST

6-3-1 General

1) Outline of Traffic Forecast Procedure

Traffic forecasts on 31 proposed roads for short/medium term projects were made to obtain traffic volume by traffic type to be used for calculation of road users' cost and road maintenance cost, and for estimation of future ADT on each proposed road link.

It was judged in the traffic forecasts that the modal split between highways and other transport modes such as railways and inland waterways would not be necessary. This judgement was made from the fact that the proposed roads were so planned to serve mainly for the local transportation, connecting rural areas each other or with major railway stations, riverside ports or trunk highways, and consequently, they would not be competitive with other modes.

Process and method of traffic forecasts used in this study are illustrated in Figure 6-2 and briefly explained below.

First of all, traffic zoning of the project area was made for each proposed road considering the network of existing and proposed roads together with surrounding major highways and Tambon boundaries. For each traffic zone thus confined, the population and agricultural productions were projected.

Secondly, transportation demands between zones were estimated. In the estimation of passenger traffic demand, the number of passengers per day was forecasted using a traffic distribution model of gravity type on the basis of the projected population for each traffic zone.

Freight traffic demand was estimated seperately for agricultural products and other commodities such as daily necessaries which flow with passenger movement.

The trasnportation demand of agricultural products was forecasted in terms of tonnage volume per day on the basis of the projected surplus productions of each zone. In the estimation of O/D volume, the destination was defined as zone where assembly markets exist and the origin was zone from which surplus products are shipped. Next, the transportation demands thus estimated by O/D pair were assigned to each road link by all or nothing method taking minimum traveling time as a sole yardstick.

The non-agricultural freight volumes on each link were estimated from the relationship with number of passengers on the same road link.

These traffic movements on road links were then converted into ADT using the traffic composition, occupancy and loading ratios applied to each link depending on its road classes. In addition, the traffic volume of motorcycle, which is not counted in ADT but is necessary for calculation of road users' benefit, was estimated analyzing the data on relationship between volume of motorcycle and ADT by road class.

Traffic surveys were carried out on and nearby the proposed roads in order to obtain information on the existing traffic characteristics such as O/D patterns and traffic composition. The traffic survey comprised origin and destination survey (O/D survey), automatic and manual traffic counts. The data obtained from the surveys were analyzed so as to set parameters of the Model and to provide various conditions required for traffic forecasting.

All traffic was forecasted dividing into normal, diverted, induced and developed traffics, in both cases of with project and without project, for the sake of calculation of road users' benefits. The forecasting was made for 1986, 1992 and 2000, the first, 7th and 15th years, respectively, after the presumed opening year of the project roads.

2) Basic Conditions for Traffic Forecasts

a) Type of Traffic

For the purpose of estimation of road users' benefits, whole traffic was classified into four types of traffic, i.e., normal, diverted, induced and developed traffic. Their definition is described below:

Normal Traffic is defined as the traffic which takes place on the existing road, arising from the natural increase of population and economic activities independent of the road improvement.

Diverted Traffic is defined as the traffic which may change its routes due to the improvement or new construction of road.

Induced Traffic is defined as the extra traffic which is newly generated as a result of improvement of transport condition such as decrease of traveling time and cost. In the estimation of induced traffic, only population with natural growth would be considered as a source of traffic, in other words, population increase by migration would be disregarded.

Developed Traffic is defined as the traffic which occurs in excess of natural growth of population and economic activities due to the agricultural development attributable to the road development.

b) Type of Vehicles

In Thailand, the present traffic can be classified into seven major types of vehicle, i.e., motorcycle, passenger car, light bus, heavy bus, light truck, medium truck and heavy truck. Since no significant change is predicted to this classification, the future traffic was also forecasted for these seven types of vehicle. Among these seven types of vehicle, there will be some difficulties to classify clearly three types of passenger car, light bus and light truck by means of the body shape of vehicle, since the so-called "pickup trucks" have been used for the mixed transportation purposes in many cases. Hence, in this study, the classification of vehicle type was made taking not only shape or capacity of vehicle but the distinctive accommodations, such as canopy of canvas, longitudinal bench seats and main purpose of car use. Standard type of vehicles and characteristics of each class are briefly described below:

i) Motorcycle (M/C)

Motorcycle is 2-wheel vehicle with engine such as Honda JX110 and Yamaha YL2GFM.

ii) Passenger Car (P/C)

Passenger car includes not only vehicles of personal use such as Toyota Corolla and Datsun 160J, but also 4-wheel-drived vehicles such as Land Rover, taxi and pickup truck used for personal use without freight transportation.

iii) Light Bus (L/B)

Light bus is a simple adoption of pickup with longitudinal bench seats and canopy of canvas. The seat capacity is 10 in average.

iv) Heavy Bus (H/B)

Heavy bus has wide range from modified 6-wheel medium trucks such as Toyota Dyna and Isuzu Elf with long bench seats to large tour buses such as Isuzu BD61 and Hino BF320. The seat capacity ranges from 20 to 40.

v) Light Truck (L/T)

Light truck is a pickup truck for freight transportation such as Toyota Hilux and Datsun 1500, with loading capacity of 2 tons.

vi) Medium Truck (M/T)

Medium truck is 6-wheel double axle truck such as Toyota Dyna and Hino KR 320, with loading capacity up to 6 tons.

vii) Heavy Truck (H/T)

Heavy truck is 10-wheel triple axle truck such as Isuzu TWD80HJ and Hino KT920, with loading capacity up to 13 tons.

c) Road Class

National highways and provincial roads on which traffic survey was conducted were classified into following four classes.

Road Class

Class	Description
1	National Highway (primary)
2	National Highway (secondary)
3	Provincial Road (paved)
4	Provincial Road (unpaved)