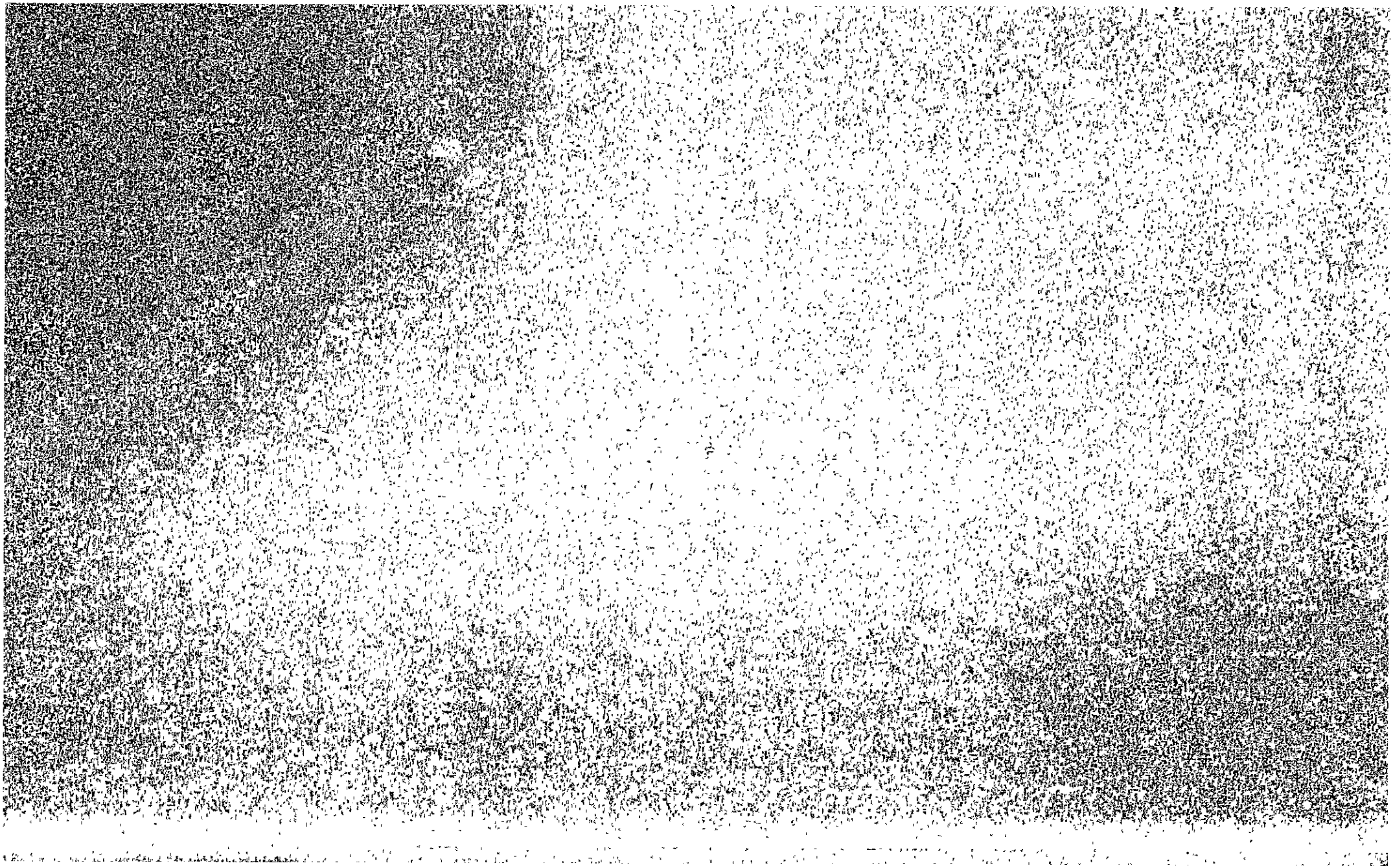
CHAPTER 2

THE REGION



CHAPTER 2

THE REGION

2.1 LAND AND ECONOMY

Thailand has total land area of 514,000 square km. The Northeastern Region occupies 168,900 square km or 33 % of the national land. Except mountain ranges of the western part of the Region and the southern part along the border with Cambodia, the land is generally flat topography with altitude of 100 - 200 meters.

Annual average rainfall in the Region is about 1,400 mm as shown in Appendix 2.1. It varies within the Region ranging from 940 mm in Nakhon Ratchasima to 2,240 mm in Nakhon Phanom located close to the Mekong river. About 85 - 90 % of annual rainfall concentrates in the rainy season during the period from May to October.

Temperature in Thailand is low in December and January, and high in April and May. In the Region, average lowest temperature is about 22 degree centigrade recorded in January and average highest is about 30 degree C in April. Along the Mekong river, it records lower temperature than that at south part in the Region.

Thailand has total population of 47,875,000 or 93 persons per square km in density as of 1981. The average annual growth rate during the period of 1976 - 1981 was 2.1 %. The Northeastern Region shares 34 % of the total population and accounts for 16,393,000 or 97 persons per square km in density with average annual growth rate of 2.1 %. In terms of population density the Northeastern region ranks second following the Central region. Population by region is shown in the following table:

Regional Population (1981)

Region	Population (1000 persons)		Percent Distribution	Annual Rate of Increase 1976-1981 (%)
Whole Kingdom	47,875	(93)	100	2.1
Northeastern	16,393	(97)	34	2.1
Central excld. Bangkok	10,501	(103)	22	2.0
Bangkok	5,332	(3,407)	11	3.2
Northern	9,714	(57)	20	1.4
Southern	5,935	(84)	13	2.2

Figures in parenthesis show population density (persons/km^2).

Source: National Statistical Office

In 1980, the amount of Gross Domestic Product (GDP) reached 685 billion Baht or 14,520 Baht per capita with annual average growth rate of 7.3 % during the period of 1976 - 1980. Agriculture accounts for 25 % of the total GDP following after the construction and services.

Although the Northeastern Region shares 34 % of the total population, it shares only 14 % of GDP due to the Region's low aggregate productivity. In the Region, however, contribution of agriculture to Gross Regional Product (GRP) is as comparatively high as 44 % of GRP. The share of manufacturing to GRP is lower than other regions. Relative position of the Northeastern Region in the national economy is demonstrated in the following table:

Relative Position of Northeastern Region
in National Economy (1980)

Sector	Share of Northeastern Region	Sectoral Distribution	
		Northeastern Region	Whole Kingdom
Gross Regional Product	14	100	100
Agriculture	24	44	25
Crops	26	35	19
Livestock	30	7	3
Fisheries	9	1	2
Forestry	9	1	1
Mining	6	1	2
Manufacturing	5	6	20
Trade	16	21	19
Construction & Services	11	28	34
Construction	14	6	6
Electricity & Water Supply	6	1	1
Transportation & Communication	8	4	7
Banking, Insurance & Real Estate	5	2	6
Ownership of Dwellings	12	1	1
Public Administration & Defense	14	4	4
Services	15	10	9

Source: NESDB

2.2 TRANSPORTATION

Major transportation means in the Northeastern Region include highways, railways and airlines. Each transportation mode has been developed in such a manner to connect every part of the Region with Bangkok on two major axes of Bangkok/Udon Thani and Bangkok/Ubon Ratchathani.

An overview of the transportation systems of the Region is described below.

2.2.1 Highways

The arterial highway network in the Region is formed by five primary highways and 23 secondary highways. The primary highway Route 2 originates at junction with Route 1 at Saraburi and extends to Nong Khai via Nakhon Ratchasima, Khon Kaen and Udon Thani. Route 24 which connects Nakhon Ratchasima with Ubon Ratchathani passes through the southern part of the Region. These two primary highways have vital importance as main highway artery in the Region. The other primary highways, Route 12, 22 and 23, which traverse east-westerly from Route 2 also constitute frames of highway network.

Secondary highways interwoven with primary highways share indispensable role of highway transportation in the Region. A number of provincial and rural roads supplement primary and secondary highways.

In the Region, national and provincial roads owned by DOH reached at about 1,600 km of primary highway, 3,200 km of secondary highway and 7,800 km of provincial roads.

2.2.2 Railways

The government-owned State Railway of Thailand (SRT) extends two railway lines in the Region. The northeasterly line originated at Bangkok branches at Nakhon Ratchasima to the north and the east directions, the destinations are Nong Khai and Ubon Ratchathani, respectively.

Bangkok-Nong Khai line has 624 km in length and it runs via Khon Kaen and Udon Thani. Bangkok-Ubon Ratchathani line passes three Changwat centers, Buri Ram, Surin and Si Sa Ket with the length of 575 km.

2.2.3 Aviation

The Government-owned Thai Airways operates scheduled services from Bangkok to Khon Kaen, Udon Thani and Ubon Ratchathani. From Bangkok to Udon Thani, four flights thru Khon Kaen and three direct flights are operated a week. From Bangkok to Ubon Ratchathani, one direct flight and two flights via Udon Thani are operated a week.

2.3 AGRICULTURE

2.3.1 Farm Population

Similarly with other regions in Thailand, agriculture and its related industries are the most dominant economic sector in the Region. Eighty four percent of the Region's population is shared by farm population of about 13.7 million in 1981. It consists about 42 % of total farm population of whole country. Growth rate of the Region's farm population for the past three years (1979 - 81) was 1.5 %. This low rate, comparing with 1.9 % for the total population, implicates that farmers in low productivity areas have tended to out-migrate to other regions.

Farm and Non-Farm Population

(1,000)

	Farm	Non-Farm	Total
Northeastern Region			
1979	13,269 (68)	2,424 (32)	15,793 (100)
1980	13,471 (68)	2,616 (32)	16,087 (100)
1981	13,680 (68)	2,713 (32)	16,393 (100)
growth, 79-81	1.5 %		1.9 %
Whole Country			
1979	31,358 (84)	14,756 (16)	46,114 (100)
1980	31,900 (84)	15,061 (16)	46,961 (100)
1981	32,500 (84)	15,375 (16)	47,875 (100)
growth, 79-81	1.8 %		1.9 %

Sounce: Office of Agricultural Economics (OAE), Ministry of Agriculture and Cooperatives (MAC)

Details of farm and non-farm population by Changwat are given in Appendix 2.2.

2.3.2 Natural Conditions and Land Utilization

The average annual precipitation in the Region is around 1400 mm. Water resources for cultivation are limited, especially in the dry season except Mekong river basin. Many areas such as in Loei, Khon Kaen, Chaiyaphum and Nakhon Ratchasima suffer from drought in planting seasons in case they have not enough rainfall during the rainy season.

On the other hand, many areas in the river basins of the Mekong, Chi and Mun, where drainage systems are insufficient, are often flooded in the rainy season. Especially in Nong Khai and Nakhon Phanom, fields along the Mekong river are flooded almost every year.

Farm holding land in the Region was estimated at 50,100 thousand rai in 1980 and counted about 47 % of the Region's total land. This ratio of land utilization is largest among Regions of the country of which average is 37 %. Shares of cultivated areas of the total farm land are 72 % for paddy, 20 % for upland crops and 1 % for orchards as shown in the table below. The growth of the cultivated area of paddy have tended to decline due to the limitation of cultivable land remained. The land for tree crops and horticulture also trends to reduce gradually.

Land Use

(1,000 rai)

	Farm Holding	Paddy	Upland Crops	Tree Crops, Vegetables
Northeastern Region (1)				
1975	47,497(100)	34,090(72)	7,517(16)	548(1)
1978	49,301	35,555	9,257	542
1980	50,093(100)	35,886(72)	9,266(20)	538(1)
growth 75-78	1.2 %	1.4 %	7.1 %	-0.4 %
75-80	1.1 %	1.0 %	5.3 %	-0.4 %
Whole Country (2)				
1975	112,211(100)	71,239(64)	19,953(18)	10,771(10)
1978	116,441	73,270	23,759	10,773
1980	118,999(100)	73,563(62)	25,758(22)	11,457(10)
growth 75-78	1.2 %	1.9 %	5.9 %	0 %
75-80	1.1 %	0.6 %	5.2 %	1.2 %
Ratio				
(1)/(2) 1980	42.1 %	48.8 %	38.7 %	4.7 %

Source: OAE, MAC

Details of land use condition by Changwat are given in Appendix 2.3, and land capability map for the Region is shown in Appendix 2.4.

Cultivated lands in the Region have extended mainly along the river basin areas of the Mekong, Song Khram, Mun, and Chi. Soil conditions in the existing cultivated area, however, have been getting worse, since necessary measures for soil conservation and management to improve those lands have not been taken. One of the obstructive factors for soil productivity in mainly paddy fields is the salinity affection. In the study of 1977 1/, salinity areas affected by over 8 millimo/cm (5200 P.P.M) were counted at about 5,283 thousand rai (8,453 km^2), that is around 15 % of the total paddy field. These lands will not be able to improve unless a large scale leaching system is

1/:Study of Salinity Affection in 1977 by Land Development Department.

introduced. The salinity area covers widely over the paddy fields in Udon Thani, Nakhon Phanom, Maha Sarakham, Roi Et, Chaiyaphum, Nakhon Ratchasima and Buri Ram as shown in Appendix 2.5

In view of geographical features, water resources, local markets and road conditions, land utilization for crop production in the Region is divided as follows:

Paddy Area (mainly flat land and river basin of Mekong, Song Khram, Chi and Mun, - paddy areas are more than 80% of cultivated area);

Nong Khai, Sakhon Nakhon, Nakhon Phanom, Maha Sarakham, Roi Et, Yasothon, Ubon Ratchathani, Buri Ram, Si Sa Ket and Surin.

Paddy and Upland Crops Area (mainly flat land including low hill side of 200 - 300 m elevation - upland areas are around 30% of cultivated area);

Udon Thani, Khon Kaen, Kalasin and east part of Chaiyaphum.

Upland Crop Area (hill side of over around 300 m elevation and mountainous areas - upland crops are planted more than 60% of cultivated area);

Loei, western part of Chaiyaphum and Nakhon Ratchasima. Maize grows mainly in Loei and Nakhon Ratchasima. Cassava grows in Nakhon Ratchasima and Kalasin where cassava factories are situated.

Geographical features and general features of land utilization are shown in Figure 2.3.1 and 2.3.2, and planted areas of each crop at Changwat level in 1981 are given in Appendix 2.6. Trend of planted area for 9 years from 1973 are shown in Appendix 2.7.

2.3.3 Irrigation

The irrigated area by projects of the Royal Irrigation Department were about 333 thousand ha. (2083 thousand rai) in 1980 as shown below.

Irrigation Project in Northeastern Region
under the Royal Irrigation Department
(1980)

ha (rai)

	Irrigable Area	Irrigated Area	(%)
By District			
Khon Kaen Regional Office	106,972	82,332	(24.7)
(Loei, Udon Thani, Khon Kaen, Maha Sarakham)	(668,575)	(514,575)	
Ubon Ratchathani Regional Office	208,650	140,989	(42.3)
(Sakon Nakhon, Nakhon Phanom, Ubon Ratchathani, Kalasin, Roi Et, Yasothon)	(1,304,063)	(881,181)	
Nakhon Ratchasima Regional Office	172,006	109,883	(33.0)
(Chaiyaphum, Nakhon Ratchasima, Buri Ram, Surin, Si Sa Ket)	(1,075,037)	(686,769)	
Total	487,628	333,204	(100)
	(3,047,675)	(2,082,525)	
By Basin			
Mekong River Basin	104,343	75,187	(22.6)
	(652,144)	(469,919)	
(Song Khram Basin only)	52,554	34,357	
	(328,463)	(214,731)	
Chi River Basin	178,281	123,679	(37.1)
	(1,114,256)	(772,994)	
Mun River Basin	204,524	133,858	(40.2)
	(1,278,275)	(836,613)	
Total	487,148	332,724	(99.9)
	(3,044,675)	(2,079,525)	

Sources: Water Resources Development in Thailand. Royal Irrigation Department, Ministry of Agriculture & Cooperatives.

The irrigation project areas concentrate into the basins of the Mun, Chi and Mekong mainly Song Khram. Besides the above mentioned projects, several small irrigation schemes of around 50 - 100 ha. in unit were constructed by local administrations.

As most of the existing irrigation projects are for the wet season and very few for the dry season, the water is still far behind the sufficiency for production increase. For the future development, irrigation projects for around 200 thousand ha. in northern part of Nong Khai and the down stream of the Mun and Chi are planned by the Mekong Committee of ESCAP/UN. Even in case the above new projects are implemented, the total irrigable areas in the Region will share only 7 % of the total cultivated area, or around 10 % of the total paddy areas.

Distribution of irrigation project plans is shown in Appendix 2.8.

2.3.4 Production of Major Crops

As for the planted area in the Region, paddy ranks first followed by cassava, maize, kenaf, sugarcane, cotton, groundnuts, mungbeans and soybeans in the past three years' average (1979 - 81) as shown below. In terms of planted area, paddy, cassava and kenaf have occupied major portion of the country total, counting 50%, 62% and 99% of each planted area of the country, respectively.

Planted Area & Production (1979-81 Average)

	Whole Country			Northeastern Region		
	Planted Area (1000 rai)	Production (1000 ton)	Average Yield (kg/rai)	Planted Area (1000 rai)	Production (1000 ton)	Average Yield (kg/rai)
Rice	56,714	15,270	269	28,551	5,514	193
Maize	9,428	3,103	329	2,583	792	307
Mungbeans	2,829	265	94	90	9.5	106
Soybeans	761	111	146	37	5.8	157
Groundnut	677	128	190	150	26.1	174
Cassava	6,825	15,128	2,217	4,223	9,002	2,132
Sugarcane	3,083	20,269	6,574	327	2,197	6,719
Kenaf	1,217	209	172	1,207	207	171
Cotton	889	171	192	192	42.3	220

Source: Agricultural Statistics of Thailand, OAE, MAC.

On the other hand, crop productivity in the Region was comparatively low due to the obstructive factors mentioned in 2.3.2 and 2.3.3 such as instable water supply and salinity. Except beans, sugarcane and cotton, average yields of crop products are lower than the national average. Especially, the Region's yield of paddy, mostly glutinous rice, is 30 % lower than the national average.

In spite of the hindrance factors, the production of upland crops such as cassava, sugarcane, cotton and beans increased rapidly during the past 8 years, mainly due to accelerated effects of the improvement of road networks in the Region. On the other hand, kenaf production has decreased due to the decline of demand in market. Similarly to cassava and sugarcane, however, kenaf is still the major commercial crops and its related industry is important in the Region. Sericulture is also a typical agro-industry in the Region, though production amount is not large.

General tendency in the past performance shows that the production amount of major crops in the Region did not increase corresponding to the rate of the expansion of planted area with the exception of the cases of cassava, sugarcane and cotton.

Detailed data of the past production are shown in Appendix 2.9, and trend of average yield of crops by Changwat is given in Appendix 2.10.

2.3.5 Assembling, Processing and Marketing

Most of crops in the Region are carried from farms to local assembly markets by farmers themselves, and comparatively few cases are handled directly by middlemen or local dealers.

Number of processing factories in the Region are as follows:

Number of Processing Factory in the Region

Rice mill (Capacity: more than 30 t/day)	132
Cassava Factory (Chip, Pelet, Flour)	297
Kenaf Factory (Baling, Textile)	95
Sugar Factory (Brown, Refinery Sugar)	13
Cotton Factory (Baling, Textile)	28

Large and medium size of rice mills are located mainly in Changwat centers and in urbanized Amphoe of rice producing areas.

In case of commercial crops such as maize, cassava roots, dry kenaf, ground nuts, they are dried and processed at the local assembly markets or processing facilities, and shipped out from there to markets outside of the Region or Bangkok wholesale markets mainly by highways via Route 2 and 304, or sometimes by railways.

Most of processing factories of cassava are placed along the national highways of Route 2, Route 24 and Route 304 in Nakhon Ratchasima and Khon Kaen. Kenaf factories are located in such Changwat centers as Udon Thani, Khon Kaen, Ubon Ratchathani and Nakhon Ratchasima. Large scale sugar plants of more than 600 t/day capactiy are in Changwat Udon Thani, Nakhon Phanom, Khon Kaen and Buri Ram. Kumphawapi sugar factory in Udon Thani and Nam Phong sugar factory in Khon Kaen have largest capacity of more than 5,000 t/day, and collected sugarcane more than one million tons each during seven months from November to May in 1981. Location and number of processing facilities for main products are shown in Appendix 2.11, and commodity flows of main crops from the production places are given in Appendix 2.12.

Figure 2.3.1
Figure 2.3.2

Figure 2.3.1 GEOGRAPHICAL FEATURES

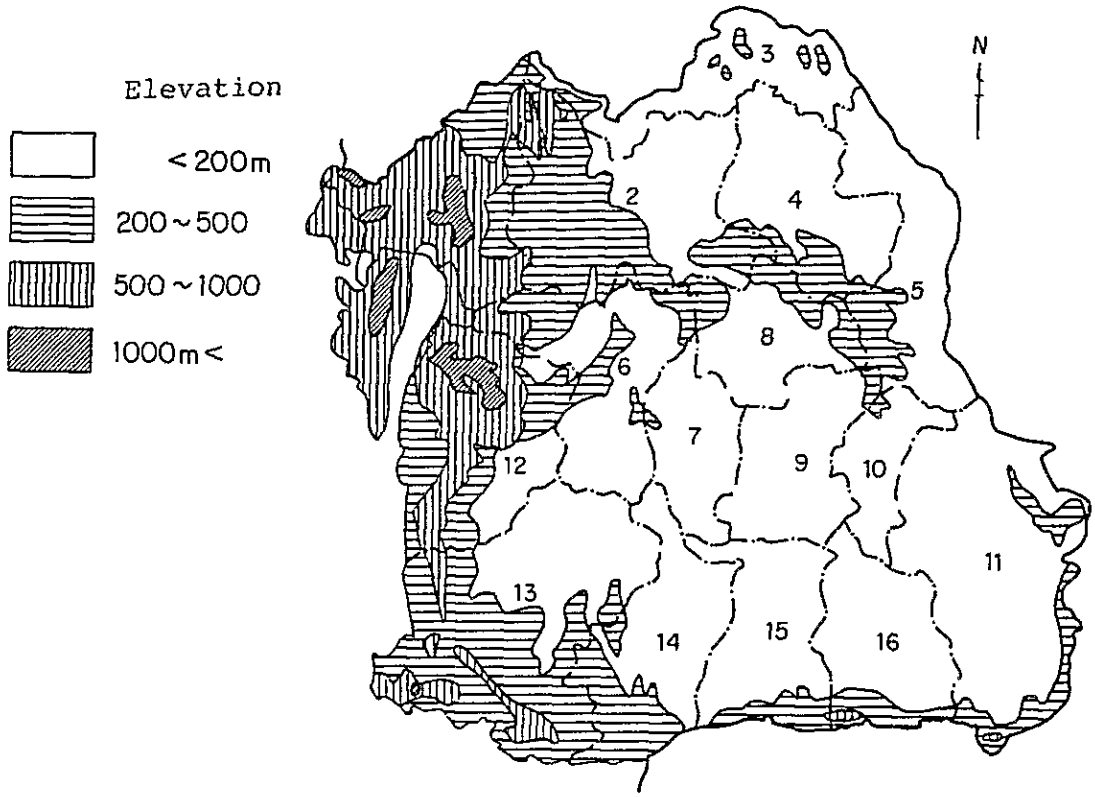
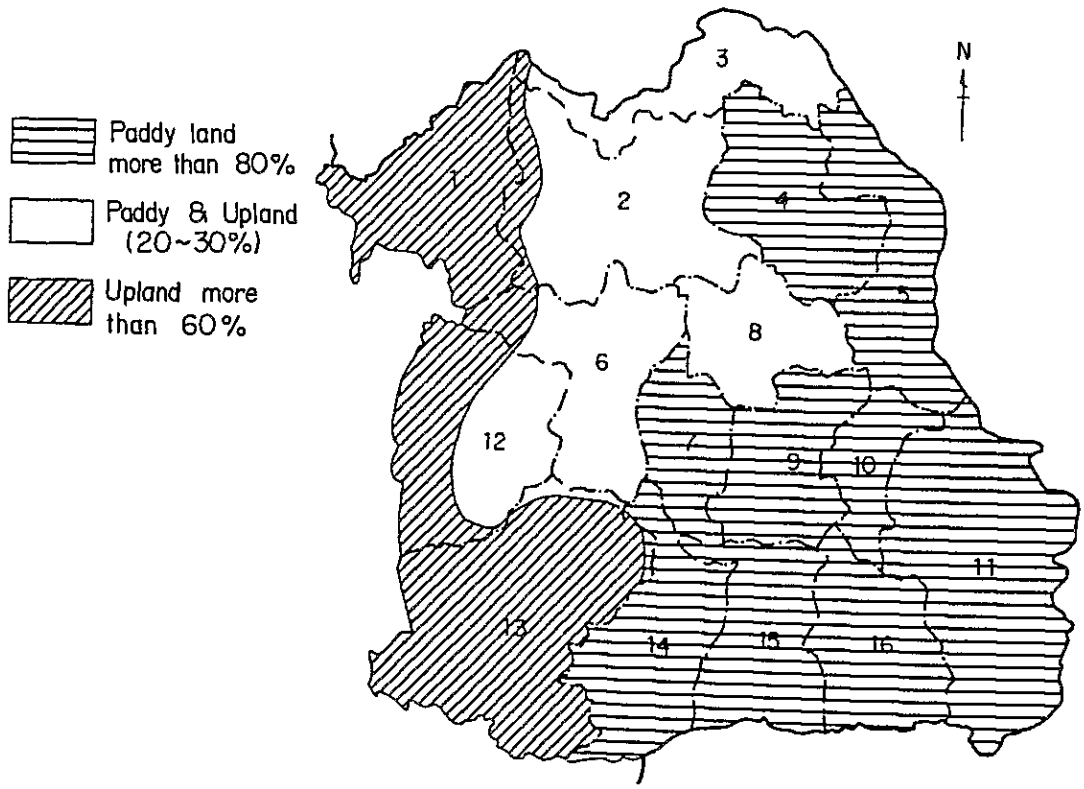


Figure 2.3.2 GENERAL FEATURES OF LAND UTILIZATION



2.4 REGIONAL DEVELOPMENT

Recent structural changes of Thailand's socio-economy have brought about tremendous benefits to the society, particularly due to rapid expansion of manufacturing and service activities in most urban areas and Bangkok Metropolis. However, there are still many people in the rural area who have not benefited from past development efforts and have hardly participated in the economic changes.

The regional economic and production structure still largely depends on agriculture. Industrial activities and economic services have not yet widely spread to the regions. This has caused a widening economic and income gap between the rural and urban people and also among regions.

To solve the above socio-economic problems, the Fifth National Economic and Social Development Plan (1982 - 1986, hereinafter referred to as the Fifth Plan) mainly stresses development objectives as follows:

- restoration of the country's economic and financial position
- adjustment of economic structure and raising of economic efficiency
- development of social structure and distribution of social services
- poverty alleviation and development of backward rural areas
- coordination of economic development activities with national security management
- reformation of the national development administration system and deconcentration of the ownership pattern.

In order to improve agricultural productivity, the Fifth Plan is emphasizing the promotion of domestic production pattern, the encouragement of the private sector to invest and develop, and the attainment of efficient use of land, water and forest resources. Stimulation of agricultural diversification is also expected to contribute to growth of agro-based industries and increase in employment opportunities.

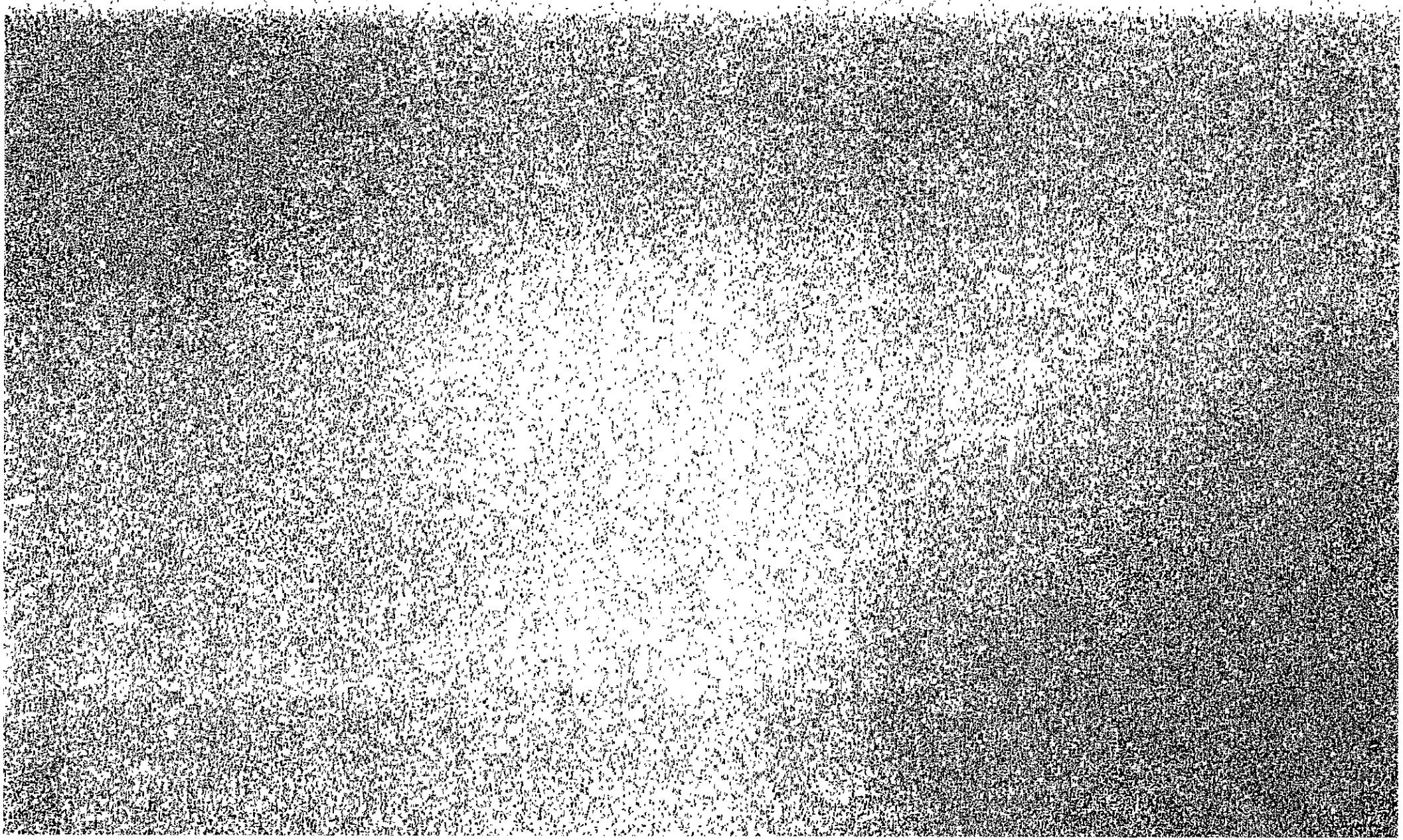
The Fifth Plan has laid down development strategies to diffuse and decentralize economic activities to the regions. In this efforts, establishment of regional urban centers has been promoted. In the Northeastern Region, cities of Khon Kaen and Nakhon Ratchasima are designated as regional urban growth centres. Linkages between regional urban centers and low-order centres are necessary in spreading favourable economic effects to the rural areas. The Fifth Plan has designated Ubon Ratchathani, Loi Et and Surin as low-order centres. Basic infrastructural facilities and social services in low-order centres are inadequate and low in quality. They are particularly short of water drainage system, flood prevention scheme, sewage and waste disposal system, portable water supply, telephone services, and traffic management, which are all vital to the economic promotion and activities of low-order centres.

Various social services like education, health and justice will be provided to meet the requirement of the population, and distributed more adequately to the rural area in order to reduce rural-urban disparity in providing social services.

One of the Fifth Plan's major objectives is development of backward rural areas in order to make them able to help themselves. It is aimed to lift the poor rural people out of absolute poverty and allow them to further improve their living standard in the long run. To achieve poverty alleviation, the government has announced "target areas" for rural development during the Fifth Plan period, covering 216 districts and 30 sub-districts in the Northeast, North and South, and has drawn up projects to these areas as much as possible. A number of projects will be implemented including village fishery projects, village water resource projects, district hospital projects, basic health services projects, soil improvement and saline soil development projects in the Northeast.

CHAPTER 3

APPROACH TO PLANNING



CHAPTER 3

APPROACH TO PLANNING

3.1 STUDY TARGET

From descriptions on the regional characteristics outlined in Chapter 2, it is envisaged that economic and social level of the Region is left behind other regions. Main cause of less-advanced economy is recognized to be due to low agricultural productivities resulted from multi-reasons as mentioned in the previous chapter. Stagnation of agricultural sector has affected the dominantly agro-dependent economy of the Region and has allowed the wide spreading of so-called poverty-stricken areas within the Region.

In compliance with the present circumstances, the Study has set its principal target to contribute to a rise of living standard of people in the Region by installing better transportation system.

With a view to realizing the said target, the Study aims to propose comprehensive plans of road development of the Region.

The immediate objectives of the Study are to identify the priority roads in terms of improvement of existing road transportation facilities and provision of new roads and to evaluate them from economic and social viewpoints.

3.2 APPROACH TO THE STUDY

The Study proceeded through two stages: road identification process of priority roads and evaluation process for the identified priority roads as given in Figure 3.1.

The subjects dealt with in this Study were broadly divided into following two items;

a) identification and evaluation of improvement and new construction roads, and

b) identification of paved roads possessing need for rehabilitation and introduction of appropriate measures for pavement restoration.

The study target needs to be translated into criteria of the project identification so that functions of identified roads are consistent with the target.

In road identification stage, proposed routes for improvement and new construction was selected by introducing the following planning criteria;

i) Socio-economic Requirement, especially for the alleviation of poverty areas,

ii) Road Network Requirement, by connecting short sections and by paving Amphoe to artery roads,

iii) National Highway Requirement, for better artery network considering roles and functions of national highways commonly employed in policies of highway development, and

iv) Bypass Requirement, needed urgently for the alleviation of traffic conjestion in and around big cities.

On the other hand, the rehabilitation studies were concerned with the upgrading of traffic capacity and service level as well as the best use of the existing roads by rehabilitating the deteriorated paved roads. Analysis of deflection and traffic data together with pavement condition survey were conducted to select the paved roads required urgently for rehabilitation.

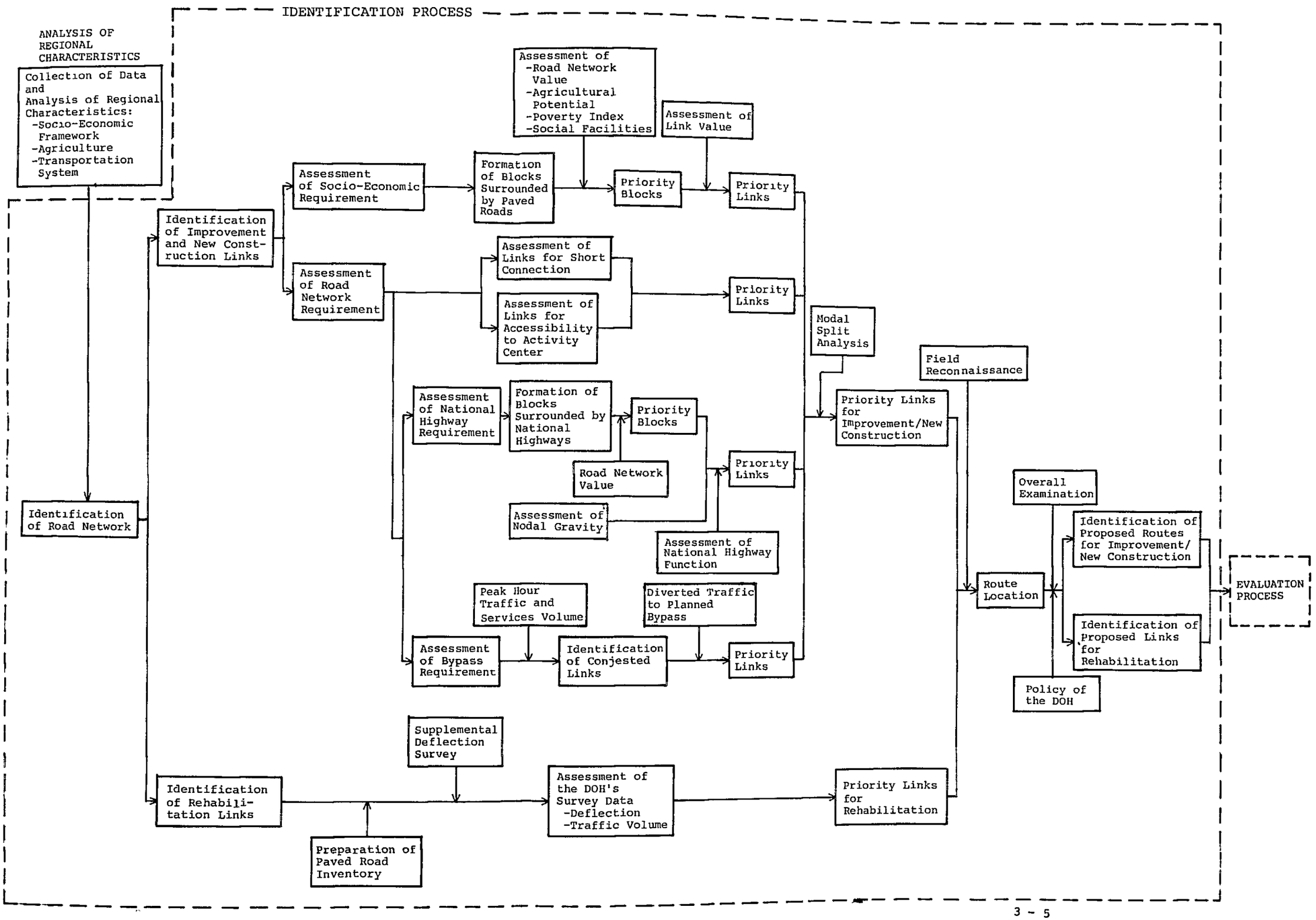
From each study subjects of improvement/new construction and rehabilitation, priority routes were identified. To supplement the outcomes from the theoretical studies, field reconnaissance survey was carried out for all projects. Through the overall examination of the study, route identification was accomplished taking the DOH's opinion into consideration.

In the evaluation stage, route analysis proceeded at prefeasibility study level in an usual cost-benefit method.

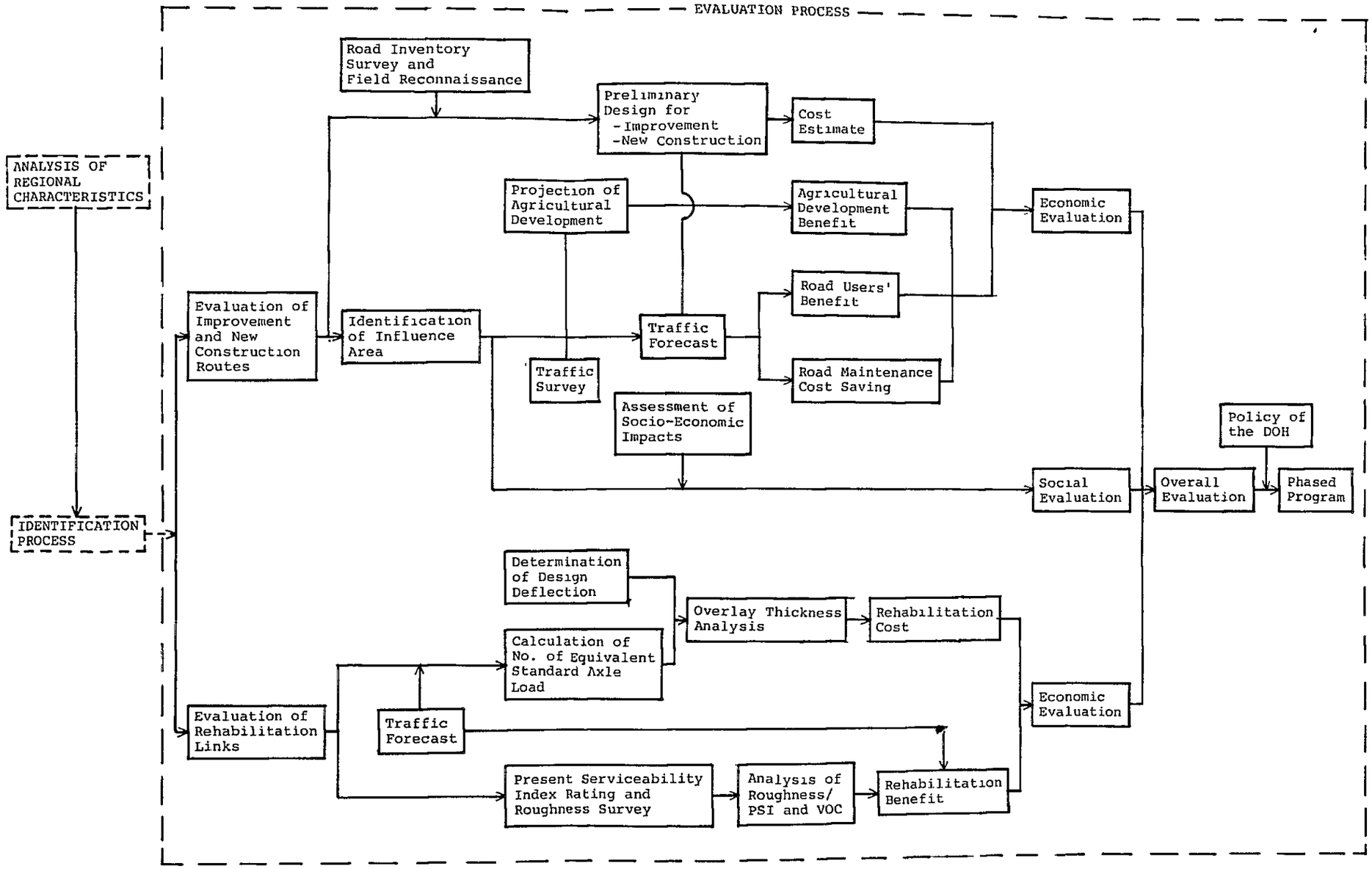
All the proposed roads were ranked in view of the economic viability and degree of social importance. Social benefits accrued from the provision of improved road system were assessed by introducing multi-functions as alleviation of isolation and income disparity, impacts on health and education services.

Finally, project phasings based on priority ranking were made classifying into Stage I program which are expected to be implemented immediately and Stage II program which are subject to further examination.

Figure 3.1 STUDY FLOW (1)

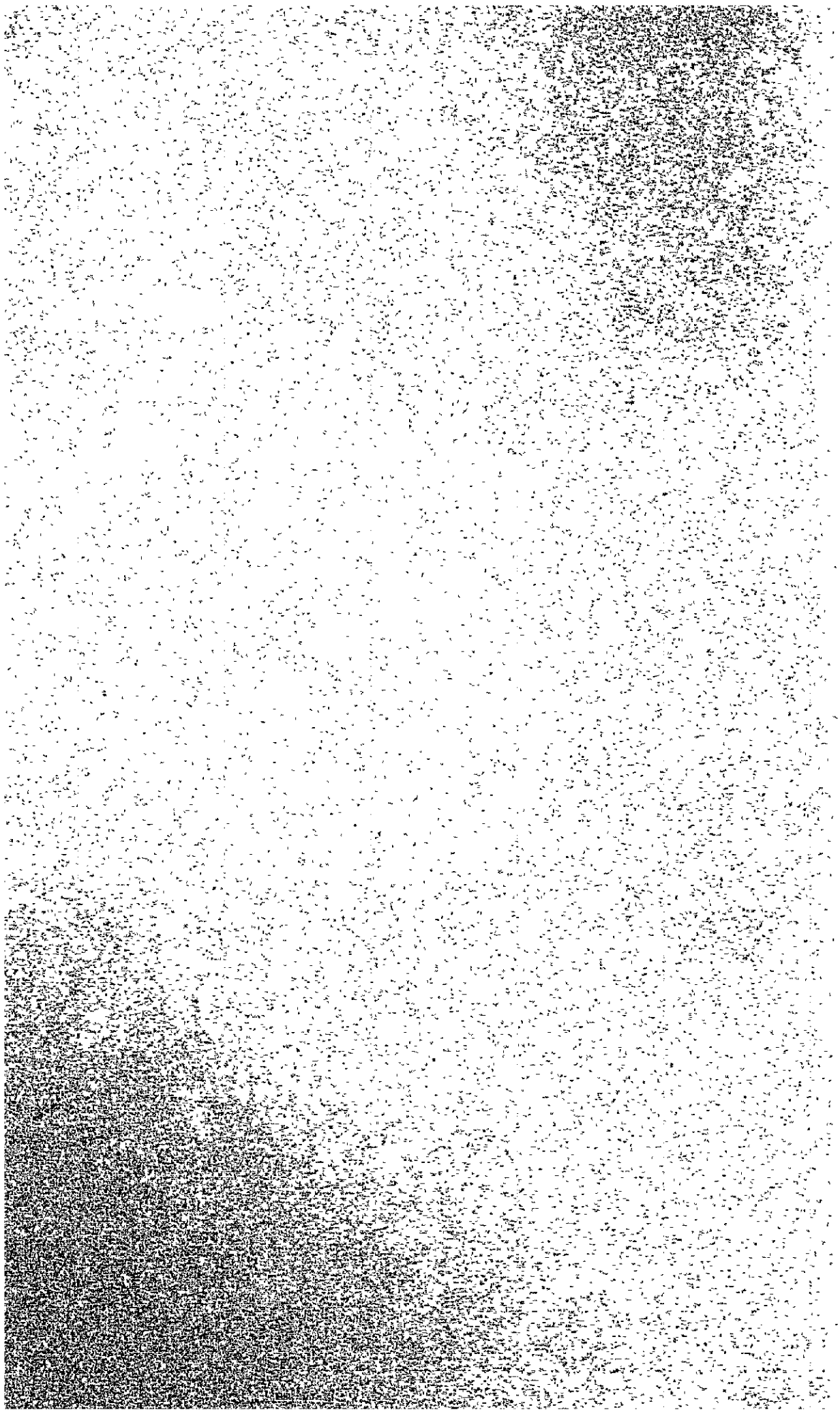


STUDY FLOW (2)


EVALUATION PROCESS
ANALYSIS OF REGIONAL CHARACTERISTICS
IDENTIFICATION PROCESS
Road Inventory Survey and Field Reconnaissance
Preliminary Design for -Improvement -New Construction
Cost Estimate
Projection of Agricultural Development
Agricultural Development Benefit
Economic Evaluation
Evaluation of Improvement and New Construction Routes
Identification of Influence Area
Traffic Survey
Traffic Forecast
Road Users' Benefit
Road Maintenance Cost Saving
Assessment of Socio-Economic Impacts
Policy of the DOH
Social Evaluation
Overall Evaluation
Phased Program
Determination of Design Deflection
Overlay Thickness Analysis
Rehabilitation Cost
Calculation of No. of Equivalent Standard Axle Load
Economic Evaluation
Evaluation of Rehabilitation Links
Traffic Forecast
Present Serviceability Index Rating and Roughness Survey
Analysis of Roughness/ PSI and VOC
Rehabilitation Benefit

CHAPTER 4

IDENTIFICATION OF ROAD NETWORK



CHAPTER 4

IDENTIFICATION OF ROAD NETWORK

4.1 EXISTING ROAD NETWORK

As the prerequisite of the road development studies, present road networks in the Region are to be identified. All national highways and provincial roads which belong to the DOH were examined on the basis of the materials such as road maps and road inventories.

National and provincial roads in the Region are mostly under the control of 20 District Offices under Nakhon Ratchasima, Khon Kaen and Ubon Ratchathani Division Offices of the DOH. Some roads at the western area of the Region belong to other three Districts under Lop Buri and Phitsanulok Divisions. Thus DOH's road network extended in the Region are controled and maintained by 23 District Offices under 5 Division Offices.

In the Region, total length of national highways is about 4,800 kilometers over 28 routes, of which 1,600 km (5 routes) are primary highways and 3,200 km (23 routes) are secondary highways. Provincial roads are 7,800 km in length over 252 routes including those transferred to the DOH for maintenance from other departments and agencies.

Length of roads in the Region totals to 12,600 km, of which 7,600 km are asphaltic concrete or surface treated while the rest are soil aggregate roads.

The length of roads by District in the Region is summarized in Appendix 4.1.

4.2 ROADS COMMITTED/PLANNED IN THE FOURTH SECTOR PLAN

Among the roads aforementioned, some roads are to be excluded from route identification works in this Study because of an agreed financial commitment for construction or studies in the Fourth Highway Sector Development Plans (Sector Plan) of the DOH. Those routes excluded are as follows:

(a) IBRD Provincial Roads Project
  18 routes (570 km) - Under construction

(b) ADB 3rd Loan Projects
  2 routes (120 km) - Under construction

(c) ADB 4th Loan Projects
  13 routes (460 km) - Listing for study

(d) ADB Provincial Road Improvement (2,000 km)
  10 routes (460 km) - Under study and detailed engineering

(e) OECF 7th Loan, Stage 2
  2 routes (40 km) - Under construction

(f) OECF 10th Loan
  6 routes (250 km) - Under study by Australian aid

(g) Government Budget
  19 routes (1,030 km) - Under construction and bidding

Total 70 routes (2,940 kilometers)

Detailed listing of those excluded routes are given in Appendix 4.2.

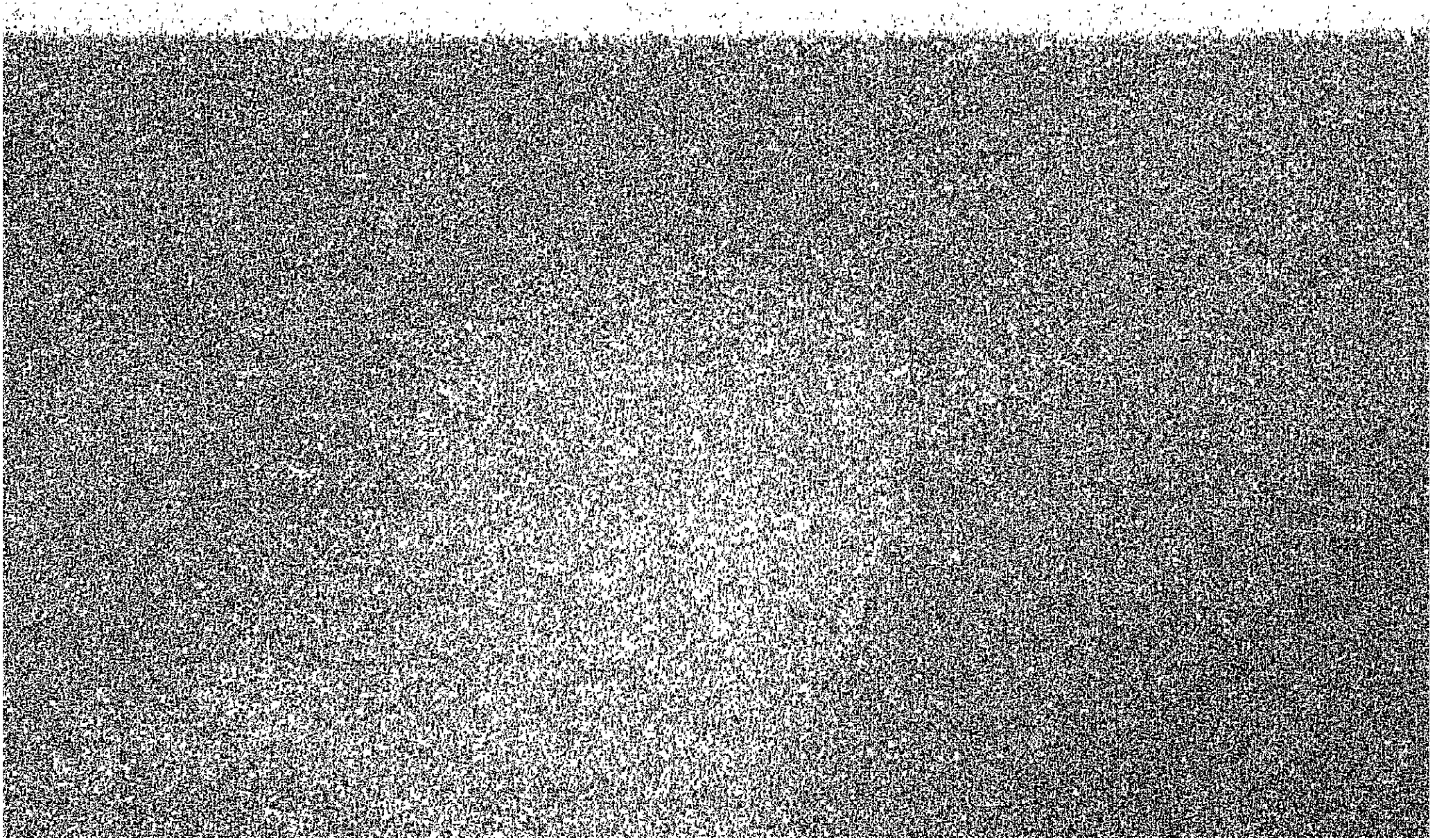
4.3 ROADS SUBJECT TO THE STUDY

Roads subject to the Study, totaling 9,600 km in length, are major roads in the Region excluding those 70 routes committed for construction, study and detailed engineering in the Sector Plan.

Existing road network together with the proposed roads committed in the Sector Plan are shown in Appendix 4.3, classifying paved and unpaved roads.

CHAPTER 5

IDENTIFICATION OF PROPOSED ROUTES FOR IMPROVEMENT AND NEW CONSTRUCTION



CHAPTER 5

IDENTIFICATION OF PROPOSED ROUTES FOR IMPROVEMENT AND NEW CONSTRUCTION

As mentioned in Chapter 3, proposed routes for improvement and new construction were identified by criteria from the following viewpoints:

i) Socio-economic requirement
ii) Road network requirement
iii) National highway requirement
iv) Bypass requirement

In the work process, first, links to be necessitated were identified individually by each above criterion mainly on a theoretical basis. Next, possibility of realization of the links theoretically identified were practically examined through the field investigation. The routes thus selected were adjusted taking the DOH's opinion into account and finally listed up as the proposed routes to be studied in the subsequent evaluation process.

5.1 IDENTIFICATION OF PRIORITY LINKS BASED ON SOCIO-ECONOMIC REQUIREMENT

5.1.1 Formation of Blocks Surrounded by Paved Road

Based on road network as of 1985 identified in Chapter 4, block areas surrounded by paved roads (national highway and provincial road) were obtained and designated as study unit (called as Block). The Blocks, 119 in total, are shown in Appendix 5.1.

5.1.2 Selection of Priority Blocks

Selection of priority Blocks was performed based on Road Network Value (M value) taking into consideration agricultural condition, poverty index and services of social facilities.

1) Road Network Value

Road Network Value (M value) of each Block was calculated by the following formula;

$$M = \frac{P}{L} \cdot \frac{A}{L}$$

where, M : Road Network Value
P : Population in the Block
A : Cultivable area in the Block
L : Total length of paved roads surrounding the Block

The cultivable area in the Block was measured based on Land Capability Map, and population in the Block was estimated allocating Amphoe population as of 1993 described in Appendix 5.2 in proportion of the cultivable area of Amphoe included in the related Block.

2) Criteria of M Value

Theoretically, required road length for the country/region is expressed by the following formula:

$$L = K \cdot \sqrt{P \cdot A}$$

where, L : Required road length
K : Road network coefficient

$$K = \alpha \cdot I$$

I : Per capita income
α : Parameter

P : Population in the area
A : Area size of cultivable land

K values on various countries were calculated and a regression line was derived from the relationship between K and I. (Appendix 5.3(1) and 5.4(1)).

According to the regression lines obtained and the following data, required lengths of paved road in the future were approximately estimated. Length of required road in 1993 in the Region was estimated to be about 13,000 km.

Basic Indicator of the Region (1993)

Population (1,000)	Cultivable Area (km2)	Per Capita GRP (B)
19,656	128,846	10,318

Using this results, marginal M value of the Block was estimated by the following formula:

$$Mc = \frac{P \cdot A}{(2L_T - L)2}$$

where, Mc : Marginal M value of the Block which needs additional paved road

P : Population of the Region

A : Cultivable area in the Region

L_T : Required total paved road length (13,000 km)

L : Road length surrounding the Region boundary (2,676 km)

The calculated Mc is about 4,000 and this figure was applied in evaluation of M value for initial selection of priority Blocks.

3) Priority Blocks

By the criteria mentioned above, the Blocks up to 74th rank of M value shown in Appendix 5.5 were selected temporarily as priority Blocks.

Production amount and gross value of agricultural production and their growth rates of the selected Blocks were calculated, based on the Amphoe data as shown in Appendix 5.6. The deviation of each item was calculated and then totaled as shown in Appendix 5.7. Blocks which have negative value in total deviation were omitted out of the priority Blocks selected by M value, considering that no significant economic benefits accrued from road improvement are expected in these Blocks. Thirty-seven Blocks among priority Blocks were omitted by the procedure mentioned above.

Using poverty index of Amphoe level, the poverty indices of Blocks were calculated as shown in Appendix 5.8 and 5.9, and 87 Blocks among 119 Blocks in total were classified as poverty Blocks.

Based on numbers of hospital and secondary school of each Amphoe, density of hospital and secondary school by Block were obtained. Their deviations were calculated respectively and then totaled as shown in Appendix 5.9.

Among Blocks previously omitted, Blocks which are of more than 60 in poverty index and positive value in total deviation of hospital/school density were revived as the priority Block from social viewpoint. Ten Blocks were revived by the procedure mentioned above.

The priority Blocks thus selected finally were 47 Blocks in total. Among them 34 Blocks were of poverty Blocks and 13 Blocks were from non-poverty Block as shown in appendix 5.10.

5.1.3 Selection of Priority Links

The links subject to the priority analysis were selected among links of unpaved provincial roads under the DOH and of other roads under other agencies which form an important road network in the priority Blocks. However, links under study or planned to be improved by other agencies were excluded from the study links.

In addition, only unpaved provincial roads under the DOH in the non-priority Blocks were also examined.

The study links totaled to 3,717.9 km of 140 links as shown in Appendix 5.11.

To analyze an extent of services that study link has against its related area, the Link Value expressed by the following formula was employed:

$$LV_i = \frac{Y_i}{L}$$

where, LV_i : Link Value
$Y_{i=1}$: Population in the related area
$Y_{i=2}$: Cultivable area in the related area
L : Length of planned link

In the above formula, related area, population and cultivable area were estimated through the following procedures:

- The related area of the link was delineated taking into account topographic features such as rivers, mountains, etc. and an extent of influence of existing roads.

- The population of the related area was estimated based on population of Tambon included in the related area.

- The cultivable area of the related area was measured based on the Lands Capability Map of scale 1 : 100,000.

An example of the above procedure is illustrated in Appendix 5.12 and 5.13.

The Link Values thus calculated by population and cultivable area were transformed to deviation value respectively and they were totaled as shown in Appendix 5.11.

Based on the calculated total deviation value, priority links were selected by the following criteria:

- Links with higher value than average total deviation of Link Values in the selected priority Blocks.

- Links with high value of total deviation of Link Values in the other Blocks.

The priority links thus selected were 1,362.5 km of 56 links and are shown in Appendix 5.11 putting three asterisk marks.

5.2 IDENTIFICATION OF PRIORITY LINKS BASED ON ROAD NETWORK REQUIREMENT

Besides analysis of Link Value, further assessment was made on links from the viewpoint of formation of desirable road network using the following criteria.

- Links which connect the activity center with the paved artery highway. (*)

- Links which form better road network by improving short sections. (**)

As a result, 260.2 km of 8 links for connection with activity center and 39.6 km of 2 links for connection of short section were selected respectively among the links which could not satisfy Link Value criteria.

They are shown in Appendix 5.11 with asterisk marks as noted above.

5.3 IDENTIFICATION OF PRIORITY LINKS BASED ON NATIONAL HIGHWAY REQUIREMENT

5.3.1 Selection of Priority Block

On the basis of the base-map of road network shown in Appendix 4.3, Blocks surrounded by paved national highway were obtained. Such Blocks are counted at 35 in number as shown in Appendix 5.14.

Road Network Value (M Value) of each Block was calculated in the same way as applied in 5.1.2. The result is shown in Appendix 5.15.

The length of national highway required in the Region was estimated by the regression line obtained from the relationship between K and I of various countries in accordance with the same way described in 5.1.2. (Appendix 5.4 and 5.5) Length of national highway required in 1993 in the Region estimated to be about 6,000 km.

The criterion of M Value (Mc) for the selection of priority Blocks was calculated by the same formula presented in 5.1.2. By giving 6,000 km into L_T and 2,231 km into L in the said formula, Mc was calculated at 22,000.

Based on the Mc thus determined, 16 Blocks were selected as the priority Blocks as shown in Appendix 5.15 and 5.16.

5.3.2 Analysis of Nodal Gravity

For calculating nodal gravity in the national highway network, 38 nodes in the Region and 1 node in Bangkok which has an important effect upon the Region were selected, and their influence area were delineated taking account of socio-economic condition, topographic features, road network system, etc. (Appendix 5.17).

The nodal gravities of each node pair were calculated by the following formula:

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

where, G : Nodal gravity
Pi, Pj : Population in the influence area of each node
L : Distance between nodes
r : Parameter (=1.3)[1/]

Gravities thus calculated were assigned to both existing national highway network and probable future national highway network. They are shown in Appendix 5.18, 5.19 and 5.20.

5.3.3 Clarification of Function of National Highway

Roles and functions which national highway has charge of were taken into consideration referring to the criteria commonly employed in policies of highway development.

For this study, functions of national highway defined in Thailand and in Japan are referred (Appendix 5.21).

5.3.4 Selection of Priority Links

Based on the above examination, priority links to be upgraded to national highway were selected using the following criteria:

- In priority Block, links which are more than 100,000 of gravity force, which indicates the minimum level of the existing national highway, were selected as priority link referring to the ADT (Average Daily Traffic) of related provincial roads.

1/: Value of parameter was referred to in the Studies on Road Development Study in the Northern Region, March 1982, JICA

- Besides, judging from the function of the national highway, the links which form better artery network and are also important for administration and connect to Changwat center or major city and pass along the border line of Kingdom were selected as priority links.

Identified priority links by the functional analysis of national highway are 1,411 km of 14 links as shown in Appendix 5.22, 5.23 and 5.24.

As shown in Appendix 5.23, Links N1, N2, N7 and N10 are paved roads. Links N3, N5 and N6 were identified through the procedures applied in 5.1 and 5.2. Link N9 was studied in Nong Bua - Ban Lam Chi Bon Highway Project and Link N8 is under study by other agency. Taking these factors into consideration, Link N4 (95 km in length) only was remained as a study link.

5.4 IDENTIFICATION OF PRIORITY LINKS BASED ON BYPASS REQUIREMENT

The process of identification of bypass routes was divided into the following three steps:

Step 1: To identify links having a large number of traffic volumes in big cities.
Step 2: To examine degree of congestion at present and in the future.
Step 3: To examine the necessity of construction of bypass routes.

5.4.1 Identification of Links of Heavy Traffic

Capital cities of eight Changwat were selected for the bypass study after examination of the locations of their existing bypasses and geographical distribution of their related cities. Traffic count was carried out in the cities selected. Count stations were selected on links of DOH roads. Number of survey points are as follows, and their locations are shown in Appendix 5.25.

Selected Cities and Number of Survey Points

Cities	Number of Survey Points
Khon Kaen	4
Udon Thani	1
Nakhon Phanom	2
Nakhon Ratchasima	2
Roi Et	1
Maha Sarakham	2
Si Sa Ket	1
Surin	2
Total	15

5.4.2 Examination of Degree of Congestion

Degree of congestion was examined using two methods in the following manuals:

- Highway Capacity Manual, 1965 (H.C.M.)
- Policy on Geometric Design of Highway in Japan, 1965 (P.G.D.H.)

Applied Items of Reduction Factors to Basic Highway Capacity

Category	Analysis based on	
	H.C.M.	P.G.D.H.
Roadway Factor	- Lane width - Lateral clearance - Grade --- combined into "track" adjustment	- Lane width - Lateral clearance - Grade --- combined into "track" adjustment - Roadside condition - Density of Intersection
Traffic Factor	- Trucks and buses - Bicycle and Motorcycle1/	- Heavy vehicle - Bicycle and Motor cycle

Note: 1/ Factors in P.G.D.H. are employed.

In H.C.M. method, the effect of motorcycle, tricycle and bicycle are not included. However, considering that those effects are significant in the traffic congestion in local cities, they are taken into account also in the analysis by H.C.M. Method as well as in P.G.D.H. Method. Input data for highway capacity analysis are shown in Appendix 5.26.

Careful comparison of the results of two methods indicated that Peak Hour Traffic Volume/Service Volume Ratio (TV/SV) under the modified H.C.M. Method gave conservative value. Hence, it is decided to identify congested links by using the modified H.C.M. Method. Links in Khon Kaen, Udon Thani, Si Sa Ket and Surin were identified as congested links, when they count over 1.2 in Peak Hour Traffic/Service Volume ratio in 1993 based on calculation results shown in Appendix 5.27. Khon Kaen, however, in which study link has the ratio exceeding 1.2, was excluded, as the DOH has a plan to widen the link. Cities and links thus identified are as follows:

City	Links	TV/SV
Udon Thani	Route 2	1.40
Si Sa Ket	Route 221	1.24
Surin	Route 214, 2077	1.24

5.4.3 Examination of Bypass Requirement

The necessity of a bypass is assessed whether the congestion can be reduced due to the expected diversion of through traffic from the congested existing links to the planned bypass.

For the forecast of expected diverted traffic, O/D Surveys were conducted for the identified three cities. According to the results of the O/D Survey, shown in Appendix 5.28, the expected diverted traffic from congested links to the planned bypass routes are estimated at 84 vehicles for Udon, 184 for Surin and 107 for Si Sa Ket. These diverted traffic are too small to reduce TV/SR ratios to 1.39 for Udon, 1.17 for Surin and 1.21 for Si Sa Ket.

In addition, after completion of roads linking directly Nakhon Ratchasima and Ubon via Surin and Si Sa Ket, some diverted traffic will be expected from Route 24 to the congested links. Traffic volumes between Nakhon Ratchasima and Ubon Ratchathani and also between Nakhon Ratchasima and Si Sa Ket were examined based on the data from O/D Survey on Route 224. As the results of the examination, expected diverted traffic were estimated only in Surin and Si Sa Ket, 56 vehicle/day and 31 vehicle/day respectively. These figures indicate that they will give no significant effect to the congested links.

It was concluded that construction of bypass is not effective mesures to resolve the congestion in the three cities.

5.5 IDENTIFIED PRIORITY LINKS

Through the theoretical assessments from various viewpoints of criteria described in the previous sections, 67 links, about 1,760 km in total, were identified as priority link. The following table shows numbers and length of priority links identified by criterion.

Number and Length of Identified Priority Links

Planning Criteria	Priority Link	
	Number	Length (km)
Socio-Economic Requirement	56	1,362.5
Road Network Requirement	10	299.8
National Highway Requirement	1	95.0
Bypass Requirement	0	0
Total	67	1,757.3

Note: Measured based on the Map of scale 1 : 100,000.

Their locations are shown in Appendix 5.29.

5.6 ANALYSIS OF MODAL SPLIT

Among the identified priority links, Link 24, 29 and 104 are located along the railway between Nakhon Ratchasima and Ubon Ratchathani. In case that they are improved, diversion of traffic to these roads from the railway may be inevitable. For estimating roughly the rate of diverted traffic, studies on competitiveness between these links after improvement and the existing railway were carried out with simple method.1/

The analysis on modal split were performed on passenger movement and commodity movement on O/D pairs of inter-Changwat and Bangkok-Region's Changwat, using data of two main railways of east bound route (Nakhon Ratchasima - Ubon Ratchathani) and north bound route (Nakhon Ratchasima - Nong Khai).

5.6.1 Modal Split for Passenger

The following factors were examined to analyze modal split for passengers.

- Distance between origin and destination
- Number of operation
- Traveling time
- Waiting time
- Fare
- Number of passenger

Generally, share of passenger by mode is explained mainly by traveling time and fare, but this analysis revealed that share of number of operation of railway would be closely correlated with the share of passenger as shown in Appendix 5.31 and 5.32.

1/: Detailed study method on modal split is shown in Appendix 5.30 as reference.

Therefore, the following formula was established for calculation of traveling cost in terms of equivalent cost incorporating waiting time in relation with number of railway operation:

$$S_i = C_i + W \cdot T_i$$

$$T_i = T_{Ti} + T_{Wi} \qquad (T_{Wi} = 24/(N_i/2/12)$$

where,
- S_i : Equivalent cost (i indicates mode)
- C_i : Fare
- W : Time cost calculated from minimum wage
- T_i : Consuming time
- T_{Ti} : Traveling time
- T_{Wi} : Waiting time
- N_i : Number of operation

The calculated equivalent costs of bus and railway and their difference are shown in Appendix 5.33. Based on the analysis of the figures, close relationship was found between share of railway passenger and difference of equivalent costs as shown below (refer to Appendix 5.34).

$$Y_R = 47.8 + 1.08\ X \qquad (r = 0.835)$$

where,
- Y_R : Share of passenger on railway
- X : Difference of equivalent costs

Based on the above, a model of modal split after improving the priority links was obtained as expressed by the following formula:

$$Y_R = Y_E + 1.08\ (Xw - X\bar{w})$$

where,
- Y_R : Share of passenger on railway after improvement
- Y_E : Present share of passenger on railway
- Xw : Difference of equivalent costs after improvement
- $X\bar{w}$: Difference of equivalent costs at present

Results of the estimation of modal split using the above model are shown in Appendix 5.35.

The analysis of modal split concluded that the rate of diversion of passengers from the railway may not be so high after the completion of direct highway along the railway.

Approximate rates of diversion from railway to bus transportation are only 10% in case of Bangkok-Changwat trips and 20% in case of inter-Changwat trips.

5.6.2 Modal Split for Commodity

Origin-destination of commodity was examined to analyze modal split of commodity flow between railway and highway. Data were collected for two kinds of O/D pairs, Bangkok-Changwat pairs and inter-Changwat pairs, as summarized in Appendix 5.36.

In case of Bangkok-Changwat O/D pairs, railway shares less than 20% of total commodity flow even in the north bound where highways pass closely along the railway. Judging from the existing tendency, no significant change in modal split between railway and highway will occur after the completion of the proposed road links in the eastern bound.

On inter-Changwat O/D pairs, as they are comparatively short distance trips, most of commodity movement is transported by road. In this case also, modal split between railway and highway is hardly changed, even if highway network along the railway in the east direction is completed.

5.6.3 Conclusion of Modal Split Analysis

Rate of diversion of passenger from the railway to highways will 10% in case of Bangkok-Changwat trips and 20% in case of inter-Changwat trips. It is regarded that such small rate of the diversion has less effect to the planning of highway development.

No diversion of commodity movement is judged to occur after improvement of related priority links.

5.7 IDENTIFICATION OF PROPOSED ROUTES

Priority links identified were derived only through theoretical analyses.

The field investigation on these priority links was carried out with DOH counterparts to check actual conditions and technical possibilities for implementation. Collection of relevant information from District Offices was also carried out.

Based on the results of the field investigation, the links which have following conditions were deleted from the study links:

- Links with extreme difficulty for construction due to topographic constraints such as steep mountains and big rivers.
- Links along which existing paved roads under other agencies are closely located.
- Links along which new roads are scheduled to be constructed by other agencies.
- Links already paved or scheduled to be paved by the DOH.
- Links passing through sensitive areas.

Succeeding the screening by link conditions mentioned above, following items were checked mainly to further clarify area potentials in the related areas of each priority link:

(a) Present condition and future prospect of the related area.

well developed or expected	o	less developed or unexpected	x

(b) Number of settlements along the link.

many	o	few	x

(c) Scale of activity center connected by the link.

large or medium	o	small	x

(d) Difficulty of acquisition of right-of-way of links under other agencies.

not difficult	o	difficult	x

Marks shown in the above, which indicate characteristics of the links and their related area, are put on the route list in Appendix 5.37.

Among them, difficulty of acquisition of right-of-way was regarded as an important criterion for selection by the DOH. Therefore, the links which have difficulty to obtain right-of-way and passing through low potential area were almost excluded.

Through the procedures mentioned above, the links omitted totaled to 31 links of 671 km and consequently the links to be further studied were 36 links of 1,183.6 km. They, regarded as temporarily proposed routes, are shown in Appendix 5.37 with selection/deletion reasons.

The result of the selection of the proposed routes were presented to the DOH for comment. DOH agreed, in principle, the results of the selection.

A list of proposed routes for improvement and new construction thus identified totaled to 33 routes of 1,183.6 km as shown in Table 5.7.1 and Figure 5.7.1.

Table 5.7.1

EW CONSTRUCTION

Proposed Route	Study1/ Route No.	Route	Route Termini		Length (km)
			Origin	Destination	
IM- 1	27	ARD	C. Kalasin	B. Khok Nong Bua (J.R.2116)	50.7
IM- 2	60	R.2259	A. Selaphum (J.R.23)	B. Kham Phon Sung (J.R.2136)	46.0
IM- 3	59				
IM- 4	44	R.2197	B. Na Hai (J.R.2049)	A. Kut Khao Pun	17.2
IM- 5	64	R.2050+ARD	A. Trakan Phut Phon (J.R.2049)	A. Khemarat (J.R.202)	65.3
IM- 6	39	R.2112+R.2173	A. Khemarat	B. Hausa Phan (J.R.217)	122.4
IM- 7	38	R.2172	B. Don Chik (J.R.217)	B.Non Riang (J.R.2182)	44.8
IM- 8	75	R.2213	B.Na Suang (J.R.24)	B. Na Yia	14.5
IM- 9	55	ARD	A. Maha Chana Chai (JR.2083)	A. Yang Chum Noi (J.R.2168)	38.2
IM-10	70				
IM-11	135	R.2076	B. Non Dang (J.R.2080,2083, 2084)	A. Rattana Buri	39.5
IM-12	96	R.2261	B. Non Khao (J.R.2079)	A. Chom Phra (J.R.214)	31.1
IM-13	118	R.2078+ARD	C. Buri Ram	Lamchi (River) (J.R.2078)	42.0
IM-14	119	R.2208+ARD+R.2078	A. Phakhon Chai (J.R.24)	A. Krasang	48.0
IM-15	100,101	R.2162	A. Huai Thalaeng	B. Ka Sang (J.R.218)	51.0
IM-16	79	R.2166	A. Lamplai Mat (J.R.2073)	B. Nong Ki (J.R.24)	59.7
IM-17	76,77	RURAL+ARD	B. Yok Kham (J.R.2309)	A. Soeng Sang (J.R.2119)	29.0
		EXTENSION OF R.24	(J.R.2)	A. Chokchai (J.R.24)	51.5

sed in the identification process.
re combined into a route.
vised through field survey.

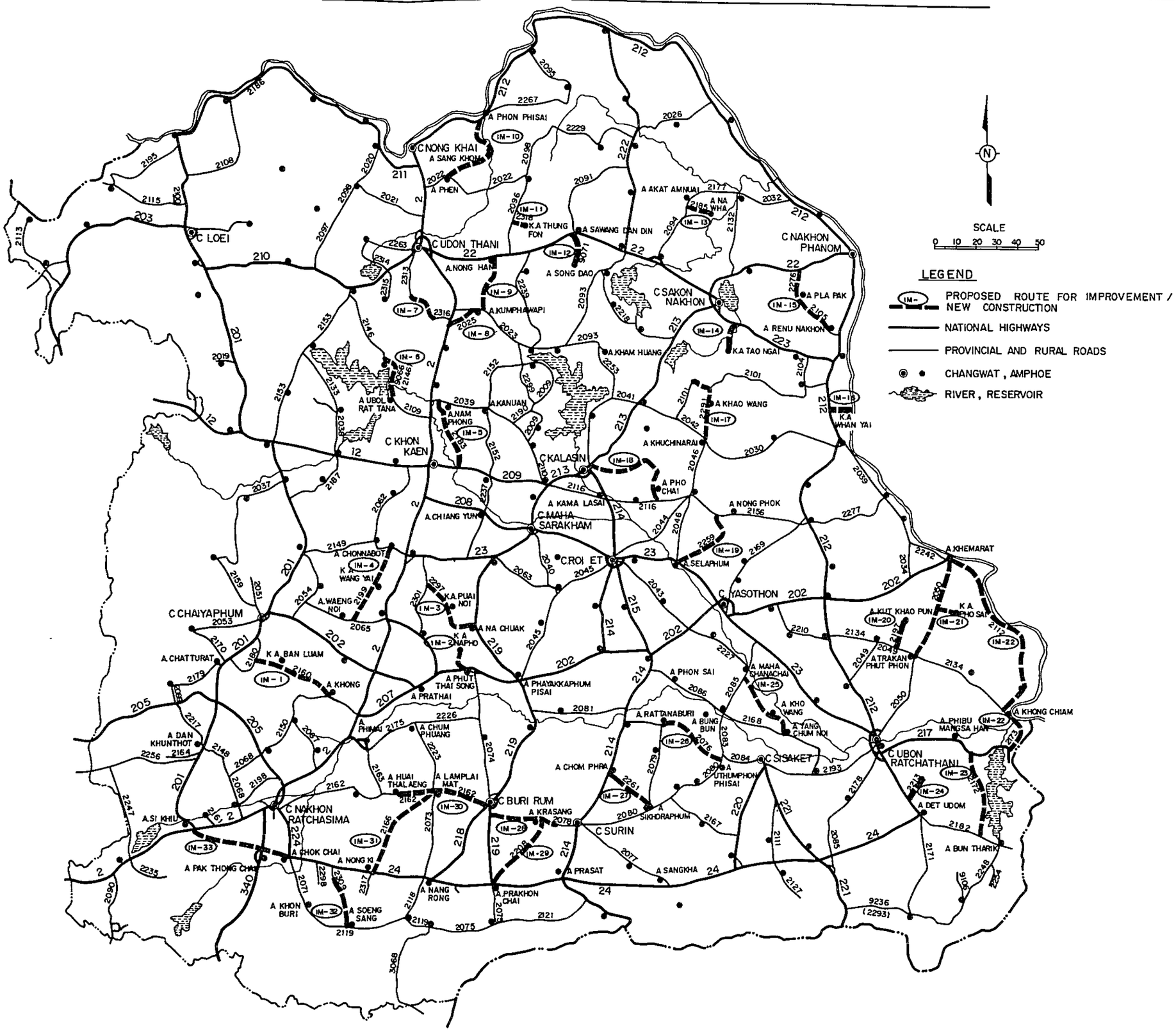
Table 5.7.1 LIST OF PROPOSED ROUTES FOR IMPROVEMENT AND NEW CONSTRUCTION

Proposed Route	Study1/ Route No.	Changwat	Route	Route Termini: Origin	Route Termini: Destination	Length (km)
IM- 1	27	Nakhon Ratchasima Chiyaphum	R.2160+ARD+Rural	A.Khong (J.R.2150,2160)	(J.R.2180)	48.0
IM- 2	60	Buri Ram	R.2061+ARD	B.Waeo (J.R.202)	K.A. Na Pho	9.4
IM- 3	59	Khon Kaen Maha Sarakam	R.2297+ARD	(J.R.2301)	A. Na Chuak (J.R.219)	30.6
IM- 4	44	Khon Kaen	R.2199	A. Chonnabot (J.R.2057)	B. Khut RU (J.R.2065)	35.3
IM- 5	64	Khon Kaen	R.2183+ARD	A. Nam Phong (J.R.2039)	(J.R.209)	29.1
IM- 6	39	Udon Thani Khon Kaen	R.2146	A. Sok Chan (J.R.2146)	Ubolratana Dam (J.R.2109)	20.3
IM- 7	38	Udon Thani	ARD	B. Khok Lat (J.R.2313)	B. Tha Yom (J.R.2316)	24.0
IM- 8	75	Udon Thani	R.2025	B. Huai Koeng (J.R.2)	A. Kumphawapi (J.R.2023)	16.7
IM- 9	55	Udon Thani	ARD	A. Nong Han (J.R.22)	A. Kumphawapi (J.R.2023)	33.4
IM-10	70	Udon Thani	ARD	A. Phen (J.R.2022)	(J.R.212)	48.1
IM-11	135	Udon Thani Nong Khai	R.2318	B. Thung Yai (J.R.2096)	K.A. Thung Fon	8.3
IM-12	96	Sakhon Nakhon	ARD(R.9071)	A. Sawang Daen Din (J.R.22)	A.Song Dao	18.1
IM-13	118	Sakhon Nakhon Nakhon Phanom	R.2185	B. Chuam (J.R.2094)	A. Na Wha	19.8
IM-14	119	Sakhon Nakhon	ARD	(J.R.223)	K.A.Tao Ngai	12.0
IM-15	100,101	Nakhon Phanom	R.2105+ARD+R.2276	A.Renu Nakhon (J.R.2031)	B.Ku Au Khu (J.R.22)	40.1
IM-16	79	Nakhon Phanom	RURAL	(J.R.212)	K.A. Whan Yai	9.1
IM-17	76,77	Kalasin	R.2291	A. Kuchinarai (J.R.2043,2030)	B. Na Khu	30.4
IM-18	43	Kalasin Roi Et	ARD	C. Kalasin	B. Khok Nong Bua (J.R.2116)	50.7
IM-19	56	Roi Et	R.2259	A. Selaphum (J.R.23)	B. Kham Phon Sung (J.R.2136)	46.0
IM-20	21	Ubon Ratchathani	R.2197	B. Na Hai (J.R.2049)	A. Kut Khao Pun	17.2
IM-21	18	Ubon Ratchathani	R.2050+ARD	A. Trakan Phut Phon (J.R.2049)	A. Khemarat (J.R.202)	65.3
IM-22	N4	Ubon Ratchathani	R.2112+R.2173	A. Khemarat	B. Hausa Phan (J.R.217)	122.4
IM-23	98	Ubon Ratchathani	R.2172	B. Don Chik (J.R.217)	B.Non Riang (J.R.2182)	44.8
IM-24	97	Ubon Ratchathani	R.2213	B.Na Suang (J.R.24)	B. Na Yia	14.5
IM-25	99	Yasothon Si Sa Ket	ARD	A. Maha Chana Chai (JR.2083)	A. Yang Chum Noi (J.R.2168)	38.2
IM-26	30	Surin Si Sa Ket	R.2076	B. Non Dang (J.R.2080,2083, 2084)	A. Rattana Buri	39.5
IM-27	9	Surin Buri Ram	R.2261	B. Non Khao (J.R.2079)	A. Chom Phra (J.R.214)	31.1
IM-28	24	Buri Ram	R.2078+ARD	C. Buri Ram	Lamchi (River) (J.R.2078)	42.0
IM-29	25	Buri Ram Surin	R.2208+ARD+R.2078	A. Phakhon Chai (J.R.24)	A. Krasang	48.0
IM-30	29,104	Buri Ram Nakhon Ratchasima	R.2162	A. Huai Thalaeng	B. Ka Sang (J.R.218)	51.0
IM-31	28	Buri Ram	R.2166	A. Lamplai Mat (J.R.2073)	B. Nong Ki (J.R.24)	59.7
IM-32	126	Nakhon Ratchasima Buri Ram	RURAL+ARD	B. Yok Kham (J.R.2309)	A. Soeng Sang (J.R.2119)	29.0
IM-33	37	Nakhon Ratchasima	EXTENSION OF R.24	(J.R.2)	A. Chokchai (J.R.24)	51.5

Note: 1/: Cord number used in the identification process.
Contiguous links were combined into a route.
Route length was revised through field survey.

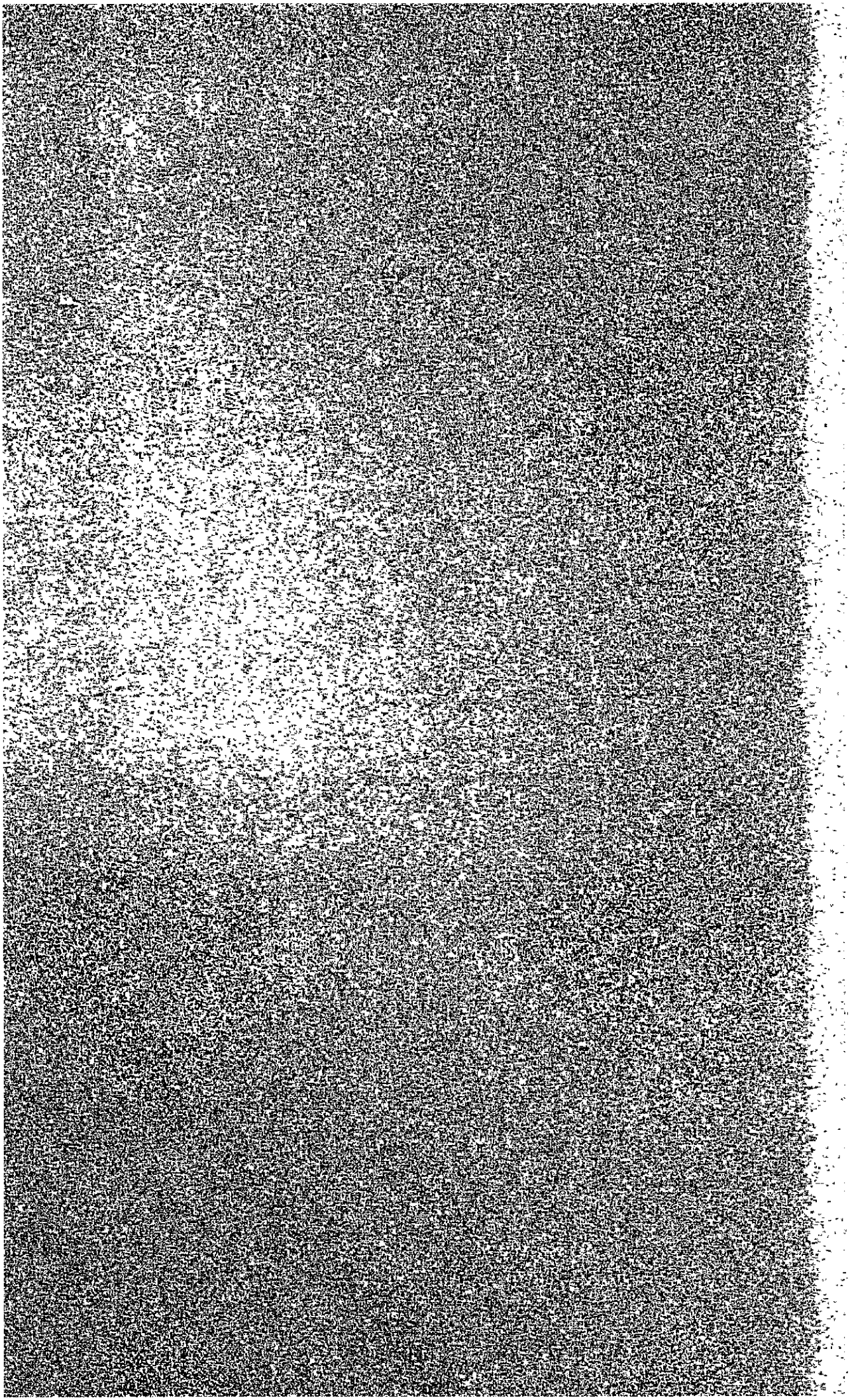
Figure 5.7.1 LOCATION OF PROPOSED ROUTES FOR IMPROVEMENT AND NEW CONSTRUCTION

Figure 5.7.1



CHAPTER 6

IDENTIFICATION OF PROPOSED LINKS FOR REHABILITATION



CHAPTER 6

IDENTIFICATION OF PROPOSED LINKS FOR REHABILITATION

6.1 PREPARATION OF PAVED ROAD INVENTORY

All paved roads subject to the rehabilitation studies were classified by road class or surface type on the basis of the highway inventories and road maps. Length of paved roads in the Region is 7,600 km, of which 4,800 km are national highways and 2,800 km are provincial roads as given in Appendix 4.1.

Road links with commitment for rehabilitation in the Sector Plan are 320 km in length over 4 routes as listed in Appendix 4.2. Those were out of objects of the Study. Roads which were paved in last three years were also excluded from the Study, as they are not so deteriorated. Those roads excluded are about 1,300 km in length.

Among the subject roads for the Study, those roads either of short length, with low traffic or located in the sensitive area, totaling 450 km were eliminated following the comments of the DOH.

Finally, road length to be subject to the Study totals to 5,600 km as schematically shown in Appendix 6.1.

6.2 DATA FOR THE STUDY

The selection of rehabilitation links in identification process was mainly based on the correlation studies of deflection of road surface and traffic volume.

6.2.1 Deflection Data

Material and Research Division of the DOH has conducted the deflection surveys for national and provincial paved roads with the instrument of Benkelman Beam. Source data surveyed are computerized for ready application to pavement design.

The existing data, however, do not cover the links for about 950 km in total length among the study links. Furthermore, among the available data for about 4,700 km, data for 8 routes of about 650 km were judged too old to be used for the Study. Thus, the existing data for about 4,000 km of the study links were used in the Study, and for the remaining sections, supplemental deflection survey was conducted.

6.2.2 Traffic Data

Traffic volume surveyed by the DOH in 1981 were available by vehicle type for most national and provincial roads in the Region. Those traffic volume were translated into the traffic flow map as shown in Appendix 6.2.

As loads imposed by passenger cars do not contribute significantly to the structural damage of roads pavements, total numbers of daily commercial vehicles only were taken into the Study.

6.3 ADDITIONAL DEFLECTION SURVEY

For roads which deflection data are either lacking or old, additional deflection survey was conducted using the deflection measurement instrument of Pavement Profiler, Model 510. The survey was conducted by the expert team of the DOH for 5 weeks from July to August 1982. The road length subjected to the deflection survey was 1,620 km over 29 routes as follows:

Deflection Survey with Pavement Profiler

Route No.	Length Surveyed (km)	Route No.	Length Surveyed (km)
12	54	2021	43
22	22	2023	28
23	177	2034	78
201	35	2038	31
202	73	2040	35
205	81	2063	37
211	45	2067	10
212	224	2074	21
213	42	2075	20
214	119	2080	29
218	51	2084	19
220	57	2111	39
221	65	2193	29
223	70	2242	7
224	29		
			1,570 km
	For comparative studies with Benkelman Beam data		50 km
	Total		1,620 km

The deflection measurement was conducted at outer wheel pass every 200 m on one lane only. Air temperature and pavement temperature for the use of deflection adjustment were also measured every one kilometer.

6.4 ANALYSIS OF DEFLECTON DATA

In view of an equi-level evaluation of data by Benkelman Beam and Pavement Profiler, deflection data of Pavement Profiler were converted to the ones of Benkelman Beam using the conversion factor of 2.0 as

suggested in SRNT.1/ Adequateness of the conversion factor of 2.0 was confirmed by the comparison of data measured with both Benkelman Beam and Pavement Profiler at same locations on Route 22 as shown in Appendix 6.3.

Each measurement data was grouped in 1 km basis and the mean of each group was calculated. The mean value was considered to represent the pavement condition of the section of 1 km. Then allowable deflection value below which the pavement may not present cracks or serious deformations was introduced to compare with each calculated mean value. While an allowable deflection limit varies with traffic, environment and subgrade conditions of road, etc., it was set at 0.6 mm referring to the past experimental studies2/ and guideline employed in overlay design of the DOH.

Each mean value was compared with the allowable deflection value. A paved section where a mean deflection value exceeds the allowable deflection was considered to be deteriorated portion.

6.5 SELECTION OF PRIORITY LINKS

The road links with deteriorated portions were selected on the basis of the following criteria in due consideration of the established practice of the DOH:

(a) Mean deflection is more than allowable deflection (= 0.6 mm),
(b) Commercial vehicles are more than 100 in number a day, and
(c) Deteriorated portions (criterion (a) above) are more than 5 km in the link.

1/: SRNT (Studies of National and Provincial Road Network in Thailand), Louis Berger International Inc. and Asian Engineering Consultants Corp., Ltd. in 1980.

2/: Evaluation of Pavements by Deflection Studies for Maintenance Purposes. Highway Research Board, No.129.

Level of traffic volume of 100 in the criterion (b) above was introduced from the studies on the relations between cumulative number of standard axle load and average deflection of a link.

By the above criteria, 93 links of 2,867 km in total were selected. They are shown in Appendix 6.4 and 6.5.

6.6 IDENTIFICATION OF PROPOSED LINKS

Priority links identified were derived only through theoretical analyses. Therefore, field investiation on these priority links was carried out with DOH counterparts to check actual conditions and technical possibilities for implementation. Collection of information from District Offices was also carried out.

Field investigation on paved roads were primarily concerned with the evaluation of surface conditions by visual inspection. Smoothness of the paved surface was also studied by checking riding qualities. Major items on deterioration indications mainly checked were crack, rutting, patching, pothole, corrugation and roughness of the surface.

Although surface conditions varied with location, surface ratings were based on the macro-assessment of the study links ignoring the local variation of conditions. Especially deteriorated portions were recorded irrespective of size of area or length together with the deterioration reasons. Rehabilitation sections overlayed or sealed recently were also recorded.

By unifying the individual ratings made by several engineers, overall evaluation for each study link was possible.

Finally overall selection of priority links were achieved by employing two major criteria, i.e., mean deflection and evaluated surface conditions of the subject link. Traffic volume on the link

was also taken into consideration. District Engineers' viewpoints or suggestions on the rehabilitation plans were greatly helpful for the link selection.

The selected links were finally 28 links of 774 km in total, of which 95 km for 3 links on Route 201 were selected owing to their notable surface deterioration. The selected links are shown in Appendix 6.6 with selection/elimination reasons.

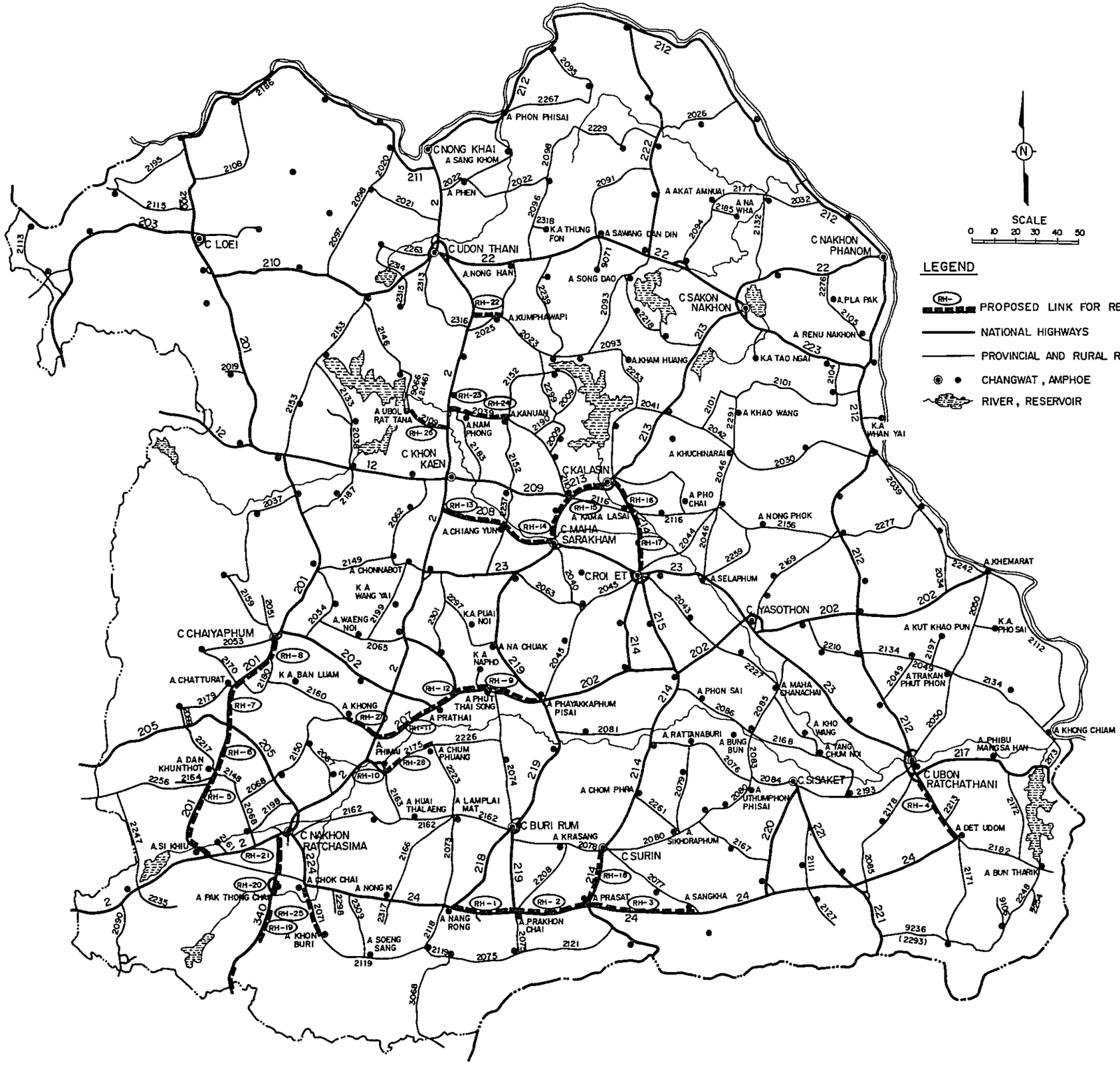
The priority links determined were shown to the DOH. DOH agreed the results of the Study in principle. The proposed routes for rehabilitation thus identified totaled to 28 links of 774 km as shown in Table 6.6.1 and Figure 6.6.1.

Table 6.6.1 LIST OF PROPOSED LINKS FOR REHABILITATION

Proposed Links								
	Link Number (*)	Route	Link	Surface Type	Link Length (Km)	Origin	Destination	Proposed Length (Km)
18	RH-1	24	400	AC	28	A. Nang Rong	A. Prakhon Chai	28
19	RH-2	24	500	AC	36	A. Prakhon Chai	A. Prasat	36
20	RH-3	24	600	AC	50	A. Prasat	A. Sangkha	50
24	RH-4	24	1001	DT	40	A. Warin Chamrap	A. Det Udom	40
26	RH-5	201	100	DT	39	A. Sikhui	A. Dan Khun Thot	39
27	RH-6	201	200	DT	25	A. Dan Khun Thot	A. Nong Bua Khok	25
28	RH-7	201	300	DT	17	A. Nong Bua Khok	A. Chatturat	17
29	RH-8	201	400	DT	38	A. Chatturat	C. Chaiyaphum	38
33	RH-9	202	500	DT	40	A. Prathai	A. Phrayakkhamphum Phisai	40
38	RH-10	206	103	AC	5	A. Phimai By Pass		5
39	RH-11	207	100	DT	37	B. Wat	A. Prathai	37
40	RH-12	207	202	DT	35	A. Prathai	A. Khok Chik	13
42	RH-13	208	100	DT	31	A. Tha Phra	A. Kosum Phisai	31
43	RH-14	208	200	DT	29	A. Kosum Phisai	C. Maha Sarakham	29
49	RH-15	213	100	DT	44	C. Maha Sarakham	A. Kalasin	44
53	RH-16	214	100	DT	28	A. Kalasin	B. Lum Chai	28
54	RH-17	214	200	DT	19	A. Lamnamchi	C. Roi Et	19
56	RH-18	214	800	PM	30	C. Surin	A. Prasat	30
69	RH-19	304	800	AC	46	A. Buphai	B. Takhop	46
71	RH-20	304	902	AC	6	A. Pak Thong Chai By Pass		6
72	RH-21	304	904	AC	26	A. Pak Thong Chai	(Route 2)	26
73	RH-22	2023	100	PM	8	B. Nam Kong	A. Si That	8
75	RH-23	2039	101	DT	16	A. Nam Phong	A. Kranuan	16
76	RH-24	2039	102	DT	17	A. Nam Phong	A. Kranuan	17
82	RH-25	2071	100	DT	28	A. Chokchai	A. Khonburi	28
88	RH-26	2109	100	DT	24	A. Nam Phong	A. Ubolratana Dam	24
93	RH-27	2160	100	DT	20	B. Wat	A. Kong	20
94	RH-28	2175	100	DT	34	B. Wang Hin	A. Chum Phuang	34
						Total		774

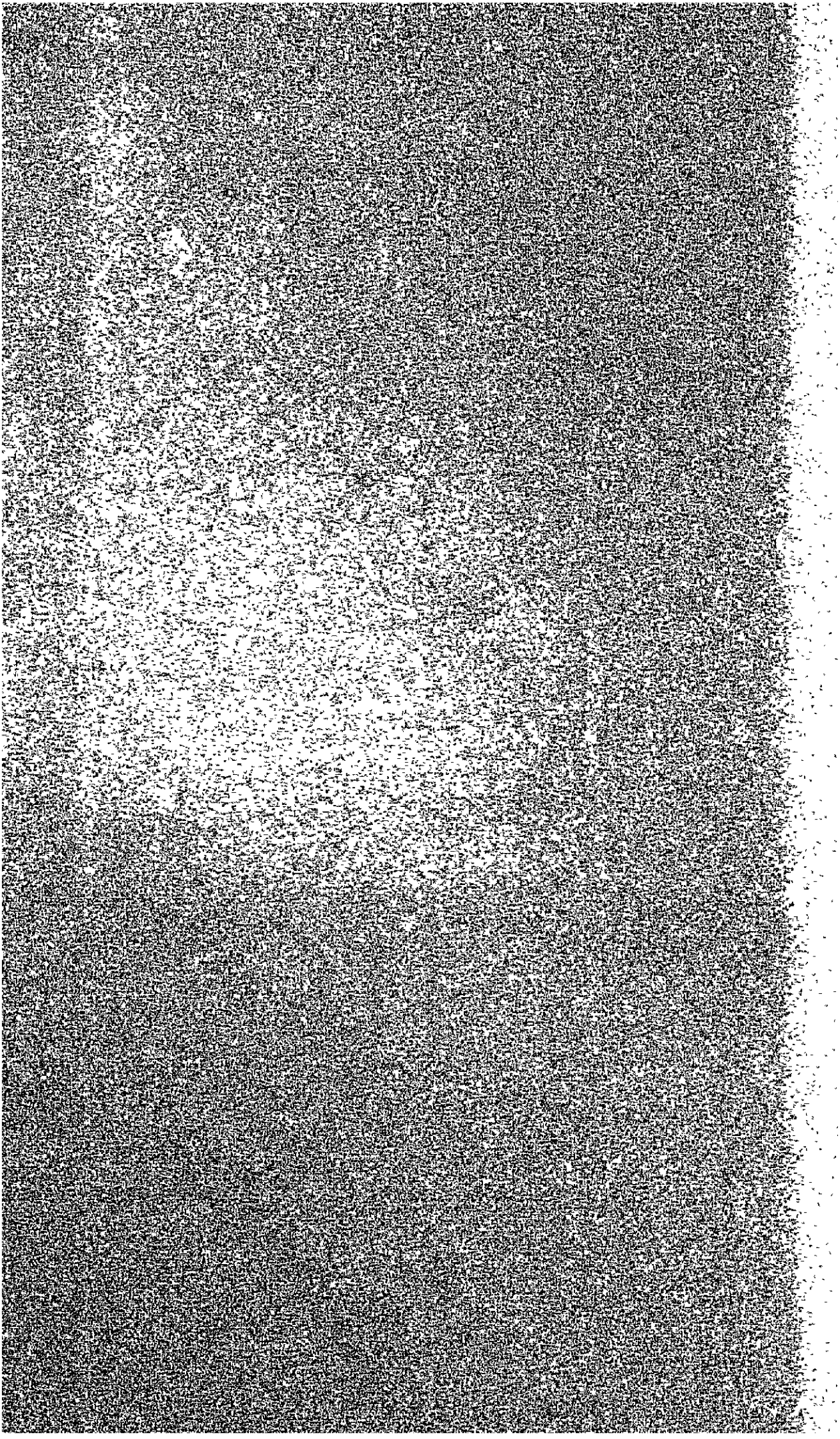
(*) Sequential Reference Number

Figure 6.6.1 LOCATION OF PROPOSED LINKS FOR REHABILITATION



CHAPTER 7

EVALUATION OF PROPOSED ROUTES FOR IMPROVEMENT AND NEW CONSTRUCTION



CHAPTER 7

EVALUATION OF PROPOSED ROUTES FOR IMPROVEMENT AND NEW CONSTRUCTION

7.1 PROPOSED ROUTES

Through the identification process, 33 routes of 1,183.6 km in total length were selected as the proposed routes to be further studied in the evaluation process. They are listed up in Table 5.7.1 and their locations are shown in a map of Figure 5.7.1.

7.2 EVALUATION FLOW

The evaluation of the proposed routes suffices to be at pre-feasibility level, for its major purpose is to determine the priority order of the proposed routes according to the degree of relative importance among them.

The flow of the evaluation process is summarized in Figure 7.2.1. The evaluation process is divided into two major parts: economic evaluation and social evaluation.

Field surveys initiates the evaluation process for the purpose to obtain primary data required for preliminary design, traffic forecast, projection of agricultural development, estimation of costs and benefits and also for the assessment of social impacts. Based on the estimated costs and benefits, economic evaluation of each proposed routes are to be carried out for the dual purposes; to clarify the economic viability of each routes and to know the priority ranking among routes. On the other hand, magnitude of social impacts of each

proposed routes are to be assessed in order to evaluate the importance of routes from the social viewpoint besides the economic viability. Finally, the overall evaluation is to be made, in due consideration of the DOH's policy, from economic and social viewpoints, to determine priority order of the proposed routes and a phased program for project implementation.

Figure 7.2.1 EVALUATION FLOW
(Route for Improvement and New Construction)