KINGDOM OF THAILAND
MINISTRY OF COMMUNICATIONS
DEPARTMENT OF HIGHWAYS

ROAD DEVELOPMENT STUDY IN THE NORTHEASTERN REGION (PHASE Ⅱ)

FINAL REPORT
TEXT
(VOLUME 1)

KINGDOM OF THAILAND
MINISTRY OF COMMUNICATIONS
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ROAD DEVELOPMENT STUDY IN THE NORTHEASTERN REGION (PHASE II)

FINAL REPORT
TEXT
(VOLUME 1)

JULY, 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to the request of the Government of the Kingdom of Thailand, the Government of Japan decided to conduct a feasibility study on the Road Network Development Project, Phase II in the Northeastern Region of Thailand and entrusted it to the Japan International Cooperation Agency (JICA).

The JICA sent to Thailand a survey team headed by Mr. Masahiko Tohi from July 8, 1984 through March 14, 1985.

The team exchanged views on the project with the officials concerned of the Government of Thailand and conducted a field survey in the region involved. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the project and contribute to the promotion of friendly relations between our two countries.

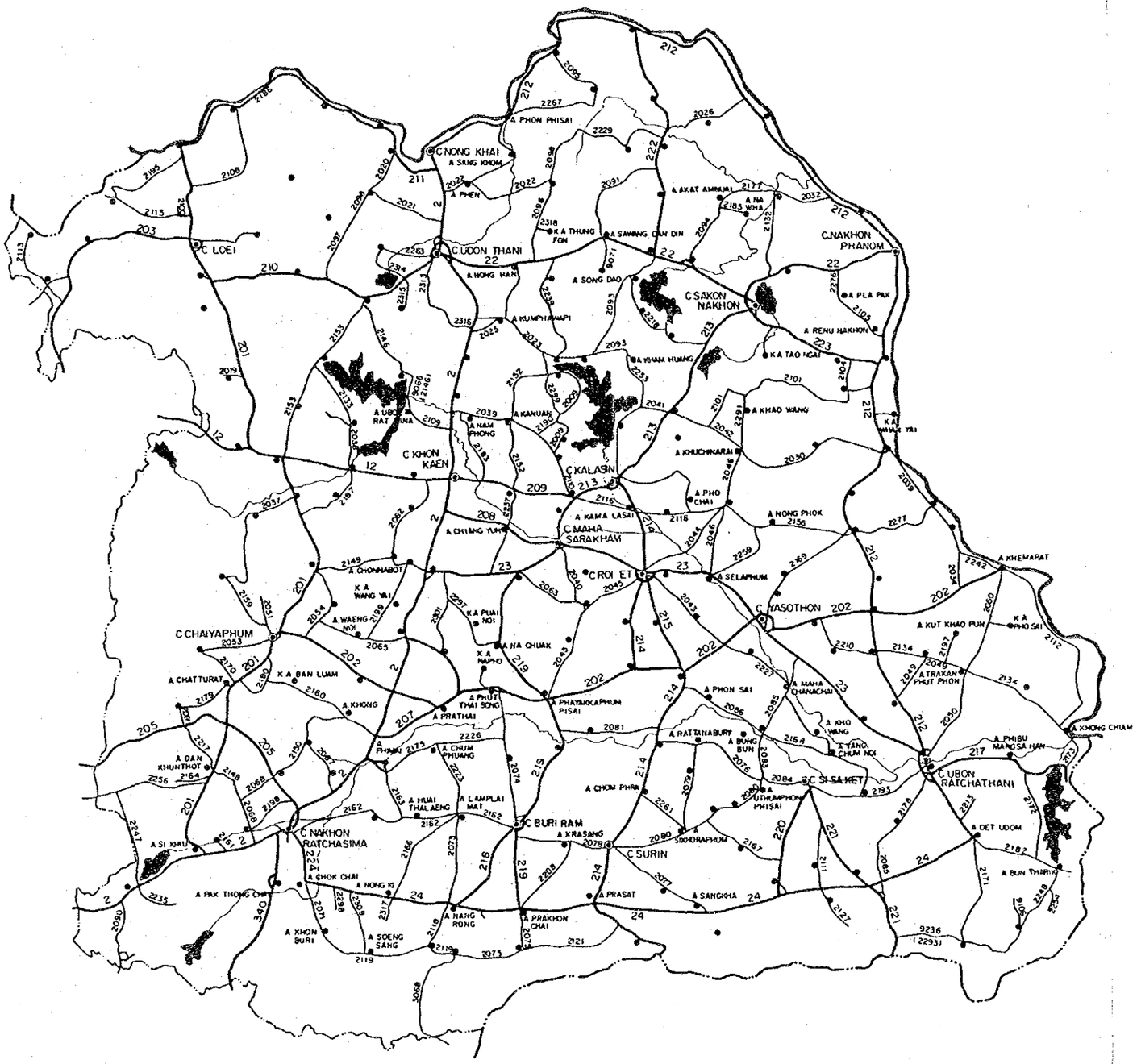
I wish to express my deep appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the team.

July, 1985

Keisuke Arita
President

Japan International Cooperation Agency

THE STUDY AREA



LEGEND

- NATIONAL HIGHWAYS
- PROVINCIAL AND RURAL ROADS
- CHANGWAT, AMPHOE
- RIVER , RESERVOIR

N

SCALE

0 10 20 30 40 50 km

IM-1: Section with no road

IM-4: Near Amphoe Wang Yai

IM-5: At beginning point (railway crossing)

IM-7: At ending point (B. Tha Yom)

IM-8: At ending point (near Ampoe Kumphawapi)

IM-9: Flooding during rainy season

IM-12: At beginning point (Amphoe Sawang Daen Din)

IM-19: Concrete bridge

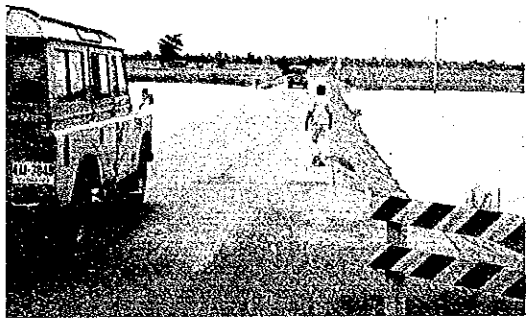
IM-24: Surface condition during rainy season

IM-25: Surface condition after rainy season

IM-26: At ending point

IM-27: Wooden bridge

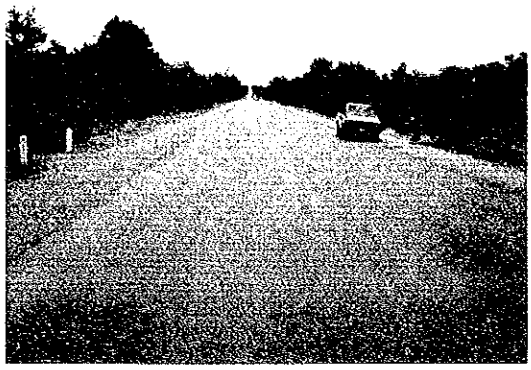
IM-29: Culvert-box under construction



IM-31: Concrete weir

IM-33: Trees utilized as bench marks

RT-224: Asphaltic concrete



RH-21: Asphaltic concrete

RH-22: Penetration macadam

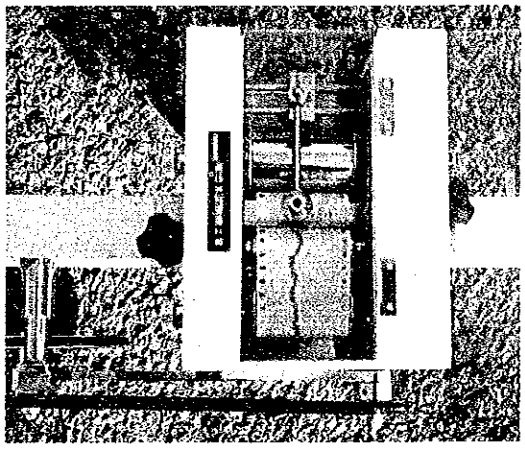
RH-5: Patching on PM pavement

RH-12: Overlay and patching on DBST pavement

RH-16: DBST pavement

RH-25: Patching on DBST pavement

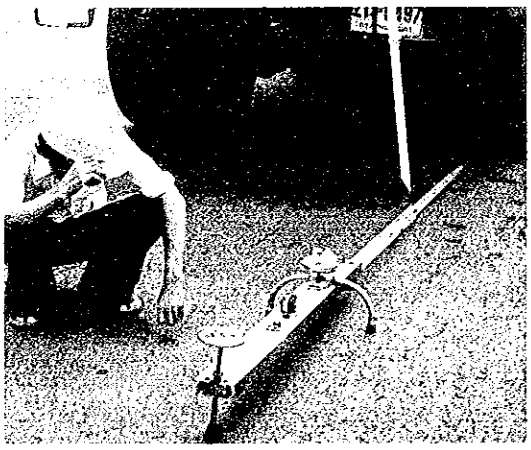
RH-27: Patching and cracks on DBST pavement



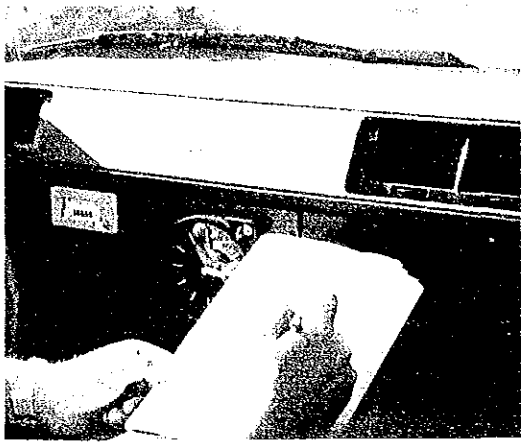
Profilometer

Cracking and patching survey

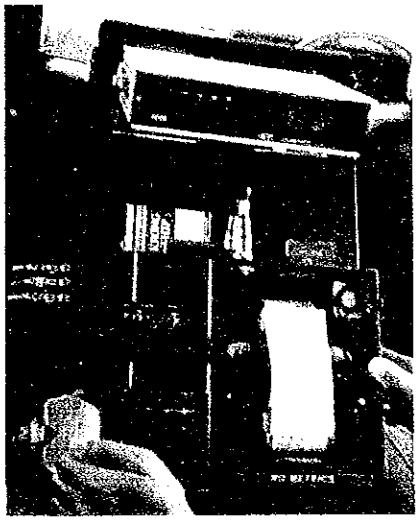
Rut depth survey



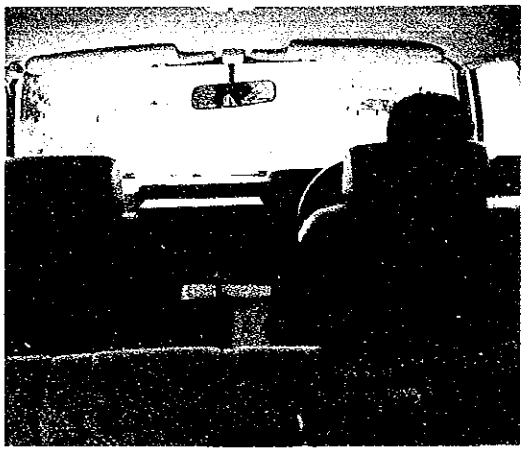
Deflection survey



Fuel consumption survey



Roughness survey



Inside of JICA inspection car

Cassava field (Changwat Nakhon Ratchasima)

Maize field (Changwat Chaiyaphum)

Puddling and transplanting of paddy

Middle scale rice mill

Kenaf factory (Changwat Udon Thaui)

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GLOSSARY

Amphoe	:	District
AADT	:	Annual Average Daily Traffic
AASHTO	:	American Association of State Highway and Transportation Officials
AC	:	Asphalt Concrete
ACI	:	Additional Crop Income in the Influence Area
ADT	:	Average Daily Traffic
AGW	:	Average Gross Weight of Heavy Trucks
AI	:	Asphalt Institute
ARD	:	Accelerated Rural Development Office
ASTM	:	American Society for Testing and Materials
A.Y.	:	Average Yield
Ban	:	Village
B/C	:	Benefit/Cost Ratio
BC	:	Base Course
BKK	:	Bangkok
C	:	Centigrade, Celsius
CBR	:	California Bearing Ratio
Changwat	:	Province
CI	:	Crop Income
cm	:	Centimeter
CRF	:	Capital Recovery Factor
CMP	:	Current Market Price
D	:	Diameter
DAD	:	Daily Average on Design Lane
DBST	:	Double Bituminous Surface Treatment
Dd	:	Design Deflection
DOH	:	Department of Highways
DTN	:	Design Traffic Number
EEC	:	European Economic Community
Ep	:	Existing Pavement Structure
Es	:	Existing Subgrade
ESA	:	Equivalent Standard Axles
ETO	:	Express Transport Organization

FSH : Feasibility Study Handbook for Improvement and New Construction Road Projects
FYRR : First Year Rate of Return

GDP : Gross Domestic Product
GPP : Gross Provincial Product
GRP : Gross Regional Product

ha : Hectare (10,000 m^2)
HRB : Highway Research Board

IBRD : International Bank for Reconstruction and Development
IRR : Internal Rate of Return
ITN : Initial Traffic Number

JICA : Japan International Cooperation Agency
JRA : Japan Road Association

kg : Kilogram
King Amphoe : Branch District
km : Kilometer
km^2 : Square Kilometer

L : length

m : Meter
mm : Millimeter
MAC : Ministry of Agriculture and Cooperatives
MRM : Mays Ride Meter
Muang : Town

NESDB : National Economic and Social Development Board
NHT : Number of Heavy Trucks
NPV : Net Present Value
NSO : National Statistical Office

° : Degree
OAE : Office of Agricultural Economics
O/D : Origin and Destination

p.a.	:	Per annum
%	:	Percent
P.A.	:	Planted Area
PM	:	Bituminous Penetration Macadam
PRI	:	Provincial Road Improvement
PSI	:	Present Serviceability Index
R	:	Radius of Curvature of Deflection
RACI	:	Regional Average Crop Income per Person
rai	:	Unit of Area (0.16 hectare)
RC	:	Reinforced Concrete
RID	:	Royal Irrigation Department
RMC	:	Road Maintenance Cost
RUCT	:	Road User Cost in Thailand
SA	:	Soil Aggregate Surfacing
SBST	:	Single Bituminous Surface Treatment
sec	:	Second
SPRP	:	Second Provincial Road Project
SPT	:	Standard Penetration Test
SRT	:	State Railway of Thailand
ST	:	Single Bituminous Surface Treatment
SVOCT	:	Standardization of Vehicle Operating Costs for Thailand
TA	:	Overlay Thickness of Asphalt Concrete
Tambon	:	Sub-District
TRRL	:	Transport and Road Research Laboratory, U.K.
via	:	By way of
VOC	:	Vehicle Operating Cost
W	:	Width

SUMMARY AND RECOMMENDATIONS

SUMMARY AND RECOMMENDATIONS

1. BACKGROUND AND SCOPE OF WORK

The Road Development Study in the Northeastern Region was carried out in two phases, Phase I (Planning) and Phase II (Feasibility Study). The Phase I Study was completed in March 1983. It identified 33 routes with a total length of 1,146.3 km for improvement or new construction and 44 routes with a total length of 774.0 km for rehabilitation. Among these, 18 routes totalling 666.9 km for improvement or new construction and 25 routes totalling 468.0 km for rehabilitation were classified as Stage I routes recommended for immediate feasibility studies.

The Phase II Study (the study) was carried out primarily for routes classified as Stage I routes in the Phase I Study. Feasibility studies for improvement or new construction routes were made for 15 routes totalling 502.1 km and case studies were done for sections totalling 90 km selected from 8 rehabilitation routes identified in advance to clarify engineering issues concerning the rehabilitation of paved roads.

2. GENERAL OUTLINE OF NORTHEASTERN REGION

The study routes are spread out over the Northeastern Region. The routes for improvement or new construction are located in 41 Amphoes in 12 of the 17 Changwats in the Region.

The Region occupies 169,500 km^2 and had a total population of 17,219,000 in 1983, both of which are one third of the respective national totals. The population growth rate in the past 5 years was 2.2%, a high figure compared with the national average growth rate of 1.8%.

The Region's gross regional product (GRP) in 1982 was 45,600 million baht at 1972 prices, which was 14.1% of the gross domestic product (GDP) of 324,300 million baht in the same year. The per capita GRP in that year was 2,658 baht, one third of the national average per capita GDP of 6,690 baht (1972 constant price).

This low income level of the Region is largely due to the low productivity of agriculture. The low productivity of the agricultural sector is primarily a result of poor natural conditions such as uneven rainfall and infertile soil. The insufficient provision of a road network in agricultural production areas is also an important factor.

Improvement of accessibility brings about an increase in the farmgate price of agricultural products and decrease in production costs, which in turn act as incentives to farmers to produce more. Improvement of the road network serving rural areas could play a very important role in realizing more efficient agricultural production and subsequent alleviation of

regional dispartities in personal income level, living standards and social environment.

3. IMPROVEMENT AND NEW CONSTRUCTION ROUTES

The study routes for improvement or new construction were evaluated by the conventional economic evaluation method which has been applied in Thailand for a number of years. In addition, a new attempt to evaluate social impacts in monetary terms was also presented.

A priority ranking of the study routes was determined by alternatively combining the above two evaluations, economic and social.

3.1 Delineation of Influence Areas

Influence areas were delineated for each study route within which population and production were considered to be affected by improvement of the study routes. Boundaries of influence areas were determined primarily on the basis of a 5 km band on both sides of each route while taking into consideration natural constraints such as large rivers and mountains, existing roads and other transport facilities such as railways.

3.2 Traffic Forecasts

Traffic forecasts were made by the "Growth Rate Method" in the case of existing roads with little prospect for traffic diversion (all routes except IM-1 and IM-33) and by the "Assignment Method" in the case of roads with missing links and with the prospect of large traffic diversion and induced traffic (IM-1 and IM-33).

Traffic surveys were carried out at 22 locations for traffic counts and 4 locations for origin and destination (O/D) surveys. In addition, a home interview survey was conducted for about 1,000 samples for the purpose of obtaining the elasticity of traffic demand.

Traffic forecasting procedures used in this study were as follows:

i) In the growth rate method, the base year traffic was estimated for each vehicle type in terms of average daily traffic (ADT) based on the results of traffic counts. In the assignment method, traffic zones were established and interzonal person trips and goods movement tonnages were estimated based on the results of the O/D survey and estimated zonal agricultural production taking into account configurations and conditions of related roads. As for non-agricultural goods traffic, a model was established which related traffic of this type to the number of person trips.

ii) Future person trips and goods movement tonnages were estimated for the cases of

"with and without project" on the basis of agricultural production growth rate and the income elasticity of person trips for the years 1988 (opening year), 1994 and 2002.

iii) Future person trips and goods movement tonnages thus estimated were converted to ADT by vehicle type by means of estimated future traffic composition, vehicle occupancy and average load.

iv) Motorcycle traffic was estimated by a model related to ADT.

3.3 Agricultural Development Benefits

Agricultural benefits due to road improvement were estimated based on an analysis of data collected in Changwat and Amphoe offices and concerned agencies in Bangkok such as the Ministry of Agriculture and Cooperatives (MAC) and universities.

Major crops in the influence areas are rice, maize, sorghum, mungbeans, soybeans, groundnuts, cassava, kenaf, sugarcane, cotton and castor beans.

Except for IM-33, cultivable land in each influence area has already been cultivated leaving only some forest land uncultivated.

In the study, the conversion of forest land was not considered given the official policy of forest conservation. However, the influence area of IM-33 still contains a substantial amount of uncultivated cultivable land, and its conversion and subsequent development benefits were taken into account.

The following factors were included in the estimation of agricultural benefits:

- Improvement in the planting area ratio of existing cultivated land
- New cultivation (IM-33 only)
- Increase in yield and farmgate prices
- Conversion of crop types
- Decrease in production cost

The increase in net value added due to the above factors was calculated for 1988, 1994 and 2002 as agricultural development benefits. Estimates for intermediate years were interpolated.

3.4 Vehicle Operating Cost Benefits

Vehicle operating cost (VOC) benefits were estimated by the method adopted by Department of Highways (DOH) with necessary updating based on the latest basic VOC data collected.

The estimation of VOC benefits was carried out by the following procedures:

i) Typical vehicles were selected and their operating costs on level tangent paved roads were calculated.

ii) Based on i), VOC at different speeds on paved roads, laterite roads under good, fair and poor condition, and earth roads was calculated.

iii) The above VOC on level tangent roads was then modified by taking into account actual restricting conditions of the study routes such as gradients, curves, narrow bridges and intersections, which affect actual VOCs.

iv) VOC benefits were estimated as the difference of total VOC in the related road network between the "with and without project" cases.

3.5 Preliminary Design

Field surveys for technical analysis and preliminary design included the following:

- Inventory survey (all study routes)
- Topographic survey (total route length of 150 km excluding routes with as-built or design drawings prepared by DOH)
- Soil sampling testings
- Pavement material testings
- Boring testings (5 locations)

DOH's existing road design standards were adopted in the study. For IM-33, which is an extension of National Highway No. 24, the P_2 standard for national highways was adopted. For the other 14 routes, the F_4 standard for provincial highways was adopted.

Proposed alignment was planned following the existing one to the fullest extent possible, considering the saving in construction costs. Modifications of existing alignments were made only where they do not satisfy DOH standards. Since no road exists for IM-33 at present, the whole length was planned as a new road. For IM-1, a 6.8 km section of missing link, and for IM-9, a section of 0.2 km in length as an anti-flood measure,were planned as new roads.

The construction of embankments was planned to be done in principle by the side borrow method and the height of embankments was planned at a minimum 70 cm above the high water level.

IM-33 was planned with asphalt concrete pavement designed by the DOH method (based on the Asphalt Institute Ms-1), while the other 14 routes were designed with DBST based

on the method presented in TRRL Road Note 31. The design period was assumed to be 7 years.

Drainage structures were designed based on calculations of discharges from the rainfall intensity data to determine location, quantity, size and other design specifications. Pipe culverts of 80–150 cm in diameter, considering ease of maintenance, and box culverts with sizes of 1.5 m × 1.5 m, 2.4 m × 2.4 m and 3.0 m × 3.0 m were adopted as standard.

It was planned that all existing wooden bridges were to be replaced by reinforced concrete bridges except for those with very short spans which were to be replaced by box culverts. The design bridge width was 11.0 m for IM-33 and 9.0 m for the remaining 14 routes in accordance with DOH standards.

Construction costs (financial) were estimated based on construction quantities and unit costs obtained by an analysis of recent construction projects in the Region. The following estimates were carried out based on the construction costs thus obtained:

- Economic costs
- Foreign and domestic cost components
- Distribution of construction cost by year based on construction procedures
- Residual values

After an analysis of DOH's maintenance budget, maintenance costs for the "with and without project" cases were determined by applying a practical way adopted by DOH. The difference between maintenance costs for the "with and without project" cases was considered as the savings in maintenance cost. An asphalt concrete overlay for IM-33 and resurfacing for the remaining 14 routes at the end of 7th year after opening were taken as the periodic maintenance.

3.6 Economic Evaluation

An economic evaluation was carried out for all study routes considering costs and benefits with the opening year of 1988 and the study period of 15 years ending in 2002.

Costs and benefits considered in the evaluation, both of which were calculated in constant 1984 prices, are as follows:

i)	Benefits	VOC savings, increase in net value added of agricultural production, maintenance cost savings
ii)	Costs	Construction cost, periodic maintenance cost, residual value (taken as negative cost)

The estimated internal rate of return (IRR) ranged from a maximum of 22.2% (IM-4) to a minimum of 8.8% (IM-7), and there were 4 routes with IRRs below 12%: IM-26, IM-7,

IM-25 and IM-27.

3.7 Evaluation of Social Impacts

An attempt was made to evaluate in monetary terms the social impact brought about by road improvement. Items considered in the study are as follows:

- Improvement in accessibility to general government services
- Improvement in educational levels
- Improvement in medical care
- Alleviation of income disparity

It was assumed that an improvement in accessibility would result in an increase in the number of times people in the influence area would use general government services or medical care services and that the cost of additional services to cope with the increased demand (salaries and overhead costs for additional government employees or medical personnel) can be considered a net benefit to the influence area population.

Improvement in accessibility to the outside world would bring about a rise in school enrollment and a corresponding requirement for additional teachers. Salaries and overhead costs for additional teachers were considered a benefit to the area.

As for the alleviation of income disparity, the increase in agricultural income in the influence area due to road improvement was reevaluated in terms of per capita income level relative to the average income level in the Region.

The sum of the above 4 social impact values was then divided by the total construction cost to yield the social impact benefit/cost (B/C) ratio for each route. The B/C ratio thus calculated ranged from a maximum of 41% (IM-4) to a minimum of 7%.

3.8 Overall Evaluation

Economic evaluation indicators were given priority in the overall evaluation. When two routes showed IRRs more than 10% apart, the ranking of the two routes was unchanged regardless of the social impact B/C ratio. When IRRs were within 10% of each other and social impact B/C ratios were more than 50% apart, the ranking determined by IRR was altered in accordance with social impact B/C ratio.

In the overall ranking determined by this procedure, study routes with IRRs below 12% (IM-26, IM-7, IM-25 and IM-27) are not placed higher than those with IRRs above 12%.

3.9 Recommendations Concerning Implementation

The minimum IRR among the study routes is 8.8% and the four routes with IRRs below 12% include those with high social impact B/C ratios. It is recommended, therefore, that preparations be commenced for acquiring necessary funds for the construction of all routes with the target opening year of 1988. The total required fund is approximately 1,039 million baht.

If the marginal rate of return is taken as 12%, the construction of IM-25 could be implemented with the target opening year of 1989, IM-7 and IM-26 with the year 1990 and IM-27 with the year 1993.

4. REHABILITATION ROUTES

The study of rehabilitation routes with 90 km of selected case study sections was carried out to clarify engineering problems such as the examination of correlationships among measured indicators including PSI, roughness, deflection, the comparison of various overlay design methods, the determination of rehabilitation plans, and the evaluation of design, costs and economic aspects based on the rehabilitation plan.

4.1 Engineering Surveys

The following engineering surveys were carried out:

- PSI by visual assessment: Assessed in accordance with the evaluation method specified in HRB Special Report 113 for every unit length of 150 m.

- PSI by measurement: Measured and compiled longitudinal irregularity (by a 3 m profilometer), cracking and patching ratio, and rut depth for every unit length of 150 m.

- Roughness: Measured by a Mays Ride Meter mounted on the JICA inspection car for every unit length of 150 m.

- Deflection: Measured at intervals of 50 m by Benkelman Beam for the center and the specified offset points.

- CBR and other tests: Field CBR tests (8 locations) and laboratory CBR tests for samples compacted in accordance with actual conditions (24 samples) were carried out. Also sampling stiffness tests of existing asphalt concrete surface materials were made (2 sites).

- Fuel consumption survey: Measured by the JICA inspection car to establish a relationship with roughness.

4.2 Correlation Analysis of Survey Results

The following correlation analyses were carried out in order to obtain data for planning and design:

In Japan as well as in the AASHTO Road Test, equations were established showing relationships between PSI obtained by visual assessment and physical measurements of longitudinal irregularity, cracking and patching rate, and rut depth. Relationships among these items were analyzed and the following equations were derived:

For asphalt concrete pavement (AC)

$$PSI = 4.354 - 1.125\log\sigma - 0.139\sqrt{C} - 0.039D^2$$

For double bituminous surface treatment pavement (DBST)

$$PSI = 4.354 - 1.579\log\sigma - 0.098\sqrt{C} - 0.015D^2$$

where, σ: Standard deviation of longitudinal irregularity (mm) (by 3.0 m profilometer)
C: Cracking and patching rate (%)
D: Rut depth (cm)

However, no equation showing a good correlation for bituminous penetration macadam pavement (PM) was found.

The following relationship was derived for PSI by visual assessment and roughness:

$$PSI = 5e^{-\left[\frac{\ell n\,(M-Mo)}{8.439}\right]^5}$$

where, M: Roughness value
Mo: Roughness under the best condition
250 mm/km for AC
1000 mm/km for DBST
1300 mm/km for PM

It was attempted to find a relationship between PSI by visual assessment and center deflection so that overlay design by PSI would be possible. No good correlation was found.

In recent years a method has been applied in that existing pavement subgrade CBR is estimated from the curvature of deflection for use as the basis of overlay design. It is necessary to

measure deflection at an offset point to obtain the curvature of deflection. If a good correlation exists between the center deflection and the curvature, it is possible to estimate the curvature from the center deflection. Analysis results yielded a relationship with a high correlation coefficient. However, since the subgrade CBRs of the case study sections measured were high, more research is required to find out whether a good correlation can also be obtained in cases with extremely low subgrade CBR.

A comparative analysis among CBR values estimated from the deflection curvature, measured in the field and measured in the laboratory for samples compacted according to actual field conditions showed that not all of the values were in good correlation as far as the case study sections are concerned. More data and research are required to develop a method of estimating subgrade CBR from the deflection curvature.

The relationship between roughness and fuel consumption was found to be almost constant at 0.0758 liter/km for roughness below 5,500 mm/km. Fuel consumption increases rapidly as roughness exceeds 5,500 mm/km at an average value of 0.1064 liter/km. Fuel consumption measurements were conducted at a running speed of 60 km/h, but for sections with roughness over 5,500 mm/km, it was possible to keep an average of only 48 km/h. These results were utilized in the calculation of VOC base data.

4.3 Traffic Loading Analysis

Cumulative numbers of equivalent standard axle (ESA) required for the overlay design were primarily estimated by using existing DOH data concerning traffic counts and vehicle loadings.

4.4 Comparison of Design Methods

In an attempt to evaluate the suitability of various overlay design methods, the following 7 methods were selected from among methods applied in a number of countries and compared in terms of their resulting overlay thickness:

- Japan Road Association Method (Road Repair and Maintenance Manual) (JRA method)
- Asphalt Institute Method (The Asphalt Institute Manual No. 17) (AI method)
- TRRL Method (TRRL Report 571) (TRRL 571 method)
- TRRL Method in the Tropics (TRRL Report 444) (TRRL 444 method)
- Overlay Thickness Formula by Ruiz (Highway Research Record 129) (Ruiz method)
- California Method (DOH method)
- Method by Radius of Curvature and Deflection (EM method)

As a result of a comparison of overlay design methods, a difference in overlay thickness required was observed. For instance, at a deflection of 1.0 mm and the same amount of

cumulative ESA, DOH and EM methods required a relatively thick overlay, the TRRL 571 and JRA methods required a moderately thick overlay and the TRRL 444, Ruiz and AI methods yielded a relatively thin overlay. These differences can be observed by comparing the design charts of each method showing the relationship among deflection, cumulative ESA and critical failure line (indicating the border between sound and failed pavement condition).

The suitability of a design method should be judged by observing and analyzing the process of overlay deterioration from the actual laying operation to failure under actual usage in the field. However, considering the fact that the thickness of actually implemented overlays in Japan and the U.S. is limited to a maximum of 50 to 60 mm, it can be said that application of a design method requiring an extremely thick overlay is not recommended. As a conclusion, it is recommended that an appropriate design method be adopted among those methods yielding a similar overlay thickness such as the JRA and AI methods.

4.5 Determination of Rehabilitation Plan

Basic concepts and methods are proposed for determining a long term plan of rehabilitation work, which is divided into three stages: identification of rehabilitation sections, determination of rehabilitation timing and rehabilitation design.

It is proposed that the identification of rehabilitation sections be based on serviceability (expressed in PSI or roughness), and that the PSI value of 2.0 be the threshold for selecting the subject section.

A model was developed which could predict the rehabilitation timing from the existing PSI and deflection together with future traffic loading. It can estimate for a pavement with an existing PSI over 2.0 the year when the PSI falls below 2.0

Proposed rehabilitation planning procedures include practical considerations. It is not recommended to simply apply overlays as determind by a design method. Construction conditions and costs should be given adequate consideration and past experience should be considered before making a final decision.

4.6 Design, Cost and Economic Evaluation

A computer model was developed based on the rehabilitation planning procedure explained above. A series of analyses were carried out by model for each 1-km section of the case study sections to determine sections requiring rehabilitation, rehabilitation timing and overlay thickness, construction cost and economic evaluation. The following comparisons were made:

- A comparison of the AI and DOH methods.
- A comparison of the case with an overlay design period of 7 years and the case with

shorter divided design periods of 4 and 3 years.

Input data to the model are measured deflection, PSI and future traffic expressed in ESA. The model operates in the following manner:

- When the existing PSI ≤ 2, overlay is immediately designed and applied. When the existing PSI > 2, the cumulative ESA at which PSI $= 2$ is calculated, and then converted to the year of overlay.
- The overlay thickness is limited to a minimum of 3.5 cm. If the calculated thickness is less than 3.5 cm, the design period is extended so that the corresponding thickness is 3.5 cm.
- If the design period which yields minimum thickness of 3.5 cm becomes more than 7 years, the residual value of overlay at the end of 7th year is calculated and is treated as a negative cost.
- In the case of dividing the overlay design period into shorter 4- and 3-year periods, the second overlay is determined by taking the first overlay into account as 80% of its actual thickness.
- The maintenance cost is calculated based on the base cost derived from DOH's budget and in proportion to PSI decrease.
- VOCs are calculated based on surface conditions (good, fair, poor) classified by PSI for each vehicle type based on the results of the fuel consumption survey.
- If the calculated overlay thickness exceeds 12 cm, this is converted into a reconstruction with a 5 cm asphalt surface course and a crushed stone base with a thickness corresponding to the remainder of the original overlay.

The IRR calculated by the model for the case study sections ranged from a maximum of 440% to a minimum of 28%. Rehabilitation work is feasible by either the AI or DOH method.

The comparison of AI and DOH methods showed the following differences: Sections requiring rehabilitation within the coming 7-year period among 90 km case study sections on 8 routes were estimated to be 22 km in 4 routes (RH-12, 16, 25 and 27) by the AI method and 35 km in 6 routes (RT-224, RH-22, 12, 16, 25 and 27) by the DOH method, with a difference of 13 km. The total overlay construction cost in the case of a 7-year design period was estimated at 9,550,400 baht by the AI method and 20,860,500 baht by the DOH method. The difference in IRR ranged from 17% to 40% in favor of the AI method.

When comparing the two design period cases, a longer 7-year period and a series of shorter 4- and 3-year periods, a difference in terms of NPV was not observed. A divided staged overlay is not necessarily economical.Designing the overlay with a design period less than 7 years is judged inappropriate considering the traffic interference due to frequent construction activities and discomfort imposed on users and residents.

4.7 Recommendations Concerning Engineering Problems

The study team's recommendations are summarized as follows:

- Rehabilitation of the case study sections are all economically feasible.

- The identification of rehabilitation sections should be based on serviceability expressed by PSI or roughness. Deflection measurements should be used for overlay design.

- The existing DOH practice of a 7-year overlay design period is appropriate. A design period shorter than this is not beneficial.

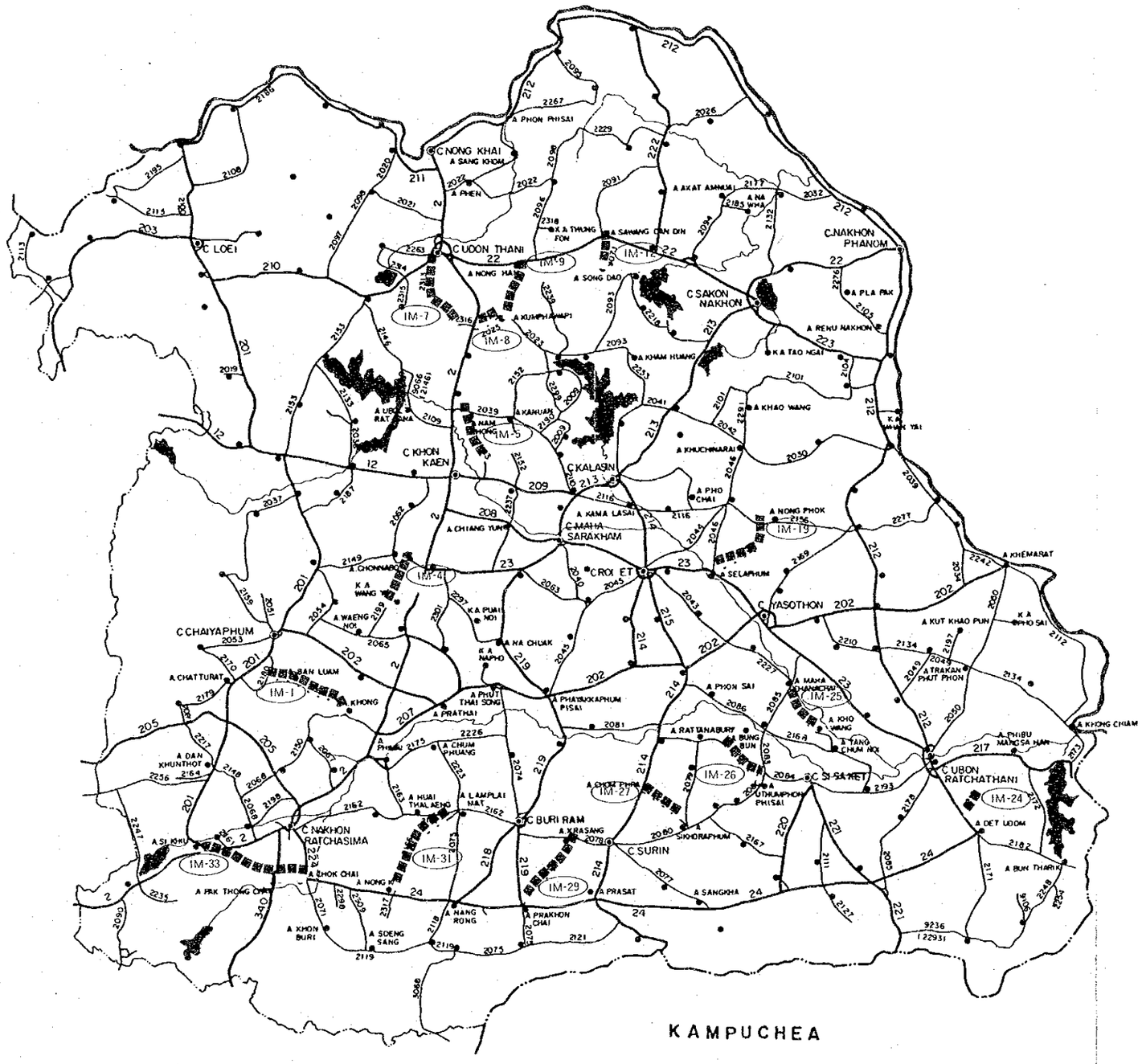
- It is difficult to judge the suitability of various design methods by desk analysis alone. However, considering the fact that in both Japan and the U.S. overlay thickness actually practiced is limited to 50 to 60 mm, the application of a method requiring an excessively thick overlay is not realistic.

- It is desirable that a simple design method be established in future by which anyone can design overlay. One such method is the JRA method which requires only deflection and daily traffic volume as input.

- The computer model developed in the study can be adopted for any design method having a design chart (showing a critical line in relation to deflection and cumulative ESA) with minor modifications. It is hoped that the model will be gainfully utilized by DOH in its future operations.

Maps of study routes and summaries of study results are shown below.

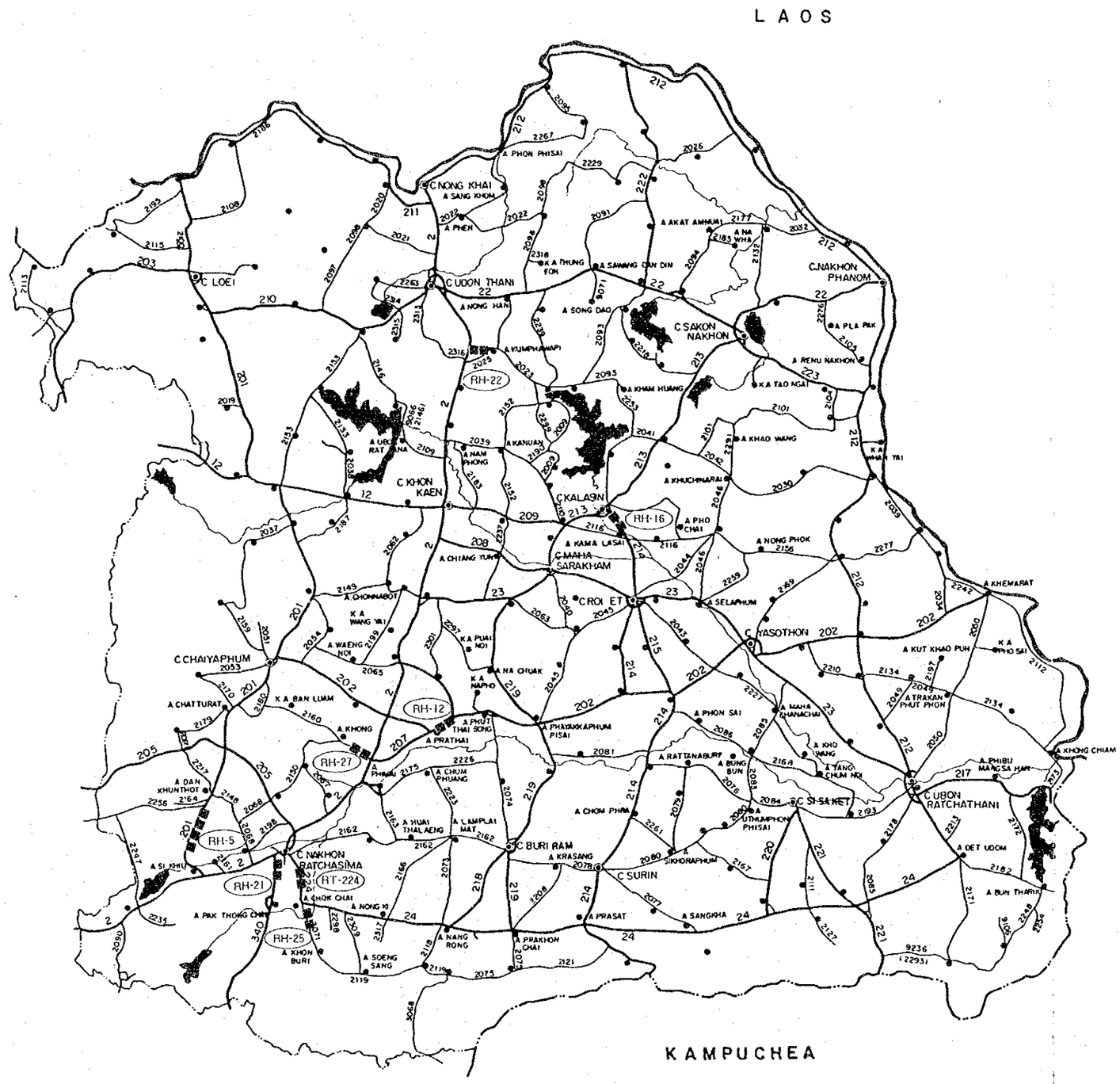
IMPROVEMENT AND NEW CONSTRUCTON ROUTES



SUMMARY OF IMPROVEMENT AND NEW CONSTRUCTION ROUTES

Route No.	Origin	Destination	Length (km)	Influence Area		Traffic Volume (ADT)		Agricultural Devt. Benefits (thousand baht)		VOC Savings (thousand baht)		Road Class	Construc-tion Cost (thousand baht)	Evalua-tion by IRR (%)	Social Impact (B/C)	Overall Ranking
				(km^2)	(1983 population)	1988	2002	1988	2002	1988	2002					
IM- 4	A. Chonnabot	B. Don Han	24.0	235	27,100	477	901	656	6,054	5,449	11,410	F4	36,433	22.2	0.413	1
IM-31	B. Nong Pha Ong	A. Nong Ki	52.6	448	51,800	317	805	2,683	12,122	9,903	23,219	F4	79,741	19.2	0.261	2
IM-33	A. Si Khiu (J.R. 2)	A. Chok Chai	51.4	372	26,200	1,453	2,696	2,157	9,504	29,476	66,473	P2	176,345	19.7	0.172	3
IM-29	A. Prakhon Chai	A. Krasang	47.1	399	51,300	302	907	1,782	11,762	10,567	24,683	F4	92,690	17.1	0.243	4
IM-50	A. Nam Phong	B. Nong Tum	28.0	189	40,400	376	924	698	4,128	6,237	14,781	F4	61,886	14.6	0.263	5
IM-19	A. Selaphum	B. Kham Phon Sung	46.3	375	48,400	235	431	2,785	6,633	10,382	20,367	F4	91,998	15.7	0.171	6
IM- 8	B. Huai Koeng	A. Kumphawapi	14.2	99	21,100	297	565	406	1,855	1,902	4,269	F4	22,274	13.5	0.400	7
IM-24	B. Na Suang	B. Na Yia	13.6	102	10,800	287	789	311	2,057	2,133	6,275	F4	26,580	14.2	0.119	8
IM- 1	A. Khong	J.R. 2180	46.8	348	33,300	294	560	1,627	6,311	9,573	18,900	F4	90,643	14.1	0.164	9
IM-12	A. Sawang Daen Din	A. Song Dao	19.1	164	15,100	275	466	1,405	2,514	3,428	6,377	F4	35,211	14.9	0.072	10
IM- 9	A. Nong Han	A. Kumphawapi	34.3	233	29,300	280	536	1,282	5,314	7,061	14,811	F4	80,463	13.1	0.154	11
IM-26	B. Som Poi Noi	B. Muang Mak	28.4	232	37,300	219	497	657	2,500	3,997	8,634	F4	47,336	11.6	0.224	12
IM- 7	B. Lao (J.R. 210)	B. Tha Yom	40.7	269	31,000	126	264	2,952	8,147	3,098	5,349	F4	65,041	11.1	0.321	13
IM-25	B. Maha Chana Chai	A. Kho Wang	24.5	218	29,500	167	473	849	1,565	4,203	7,444	F4	46,933	11.0	0.171	14
IM-27	A. Chom Phra	B. Nong Khawao	31.1	215	37,400	262	577	776	4,534	2,379	5,867	F4	50,333	8.8	0.273	15

REHABILITATION ROUTES



LEGEND

- RH- CASE STUDY SECTION
- NATIONAL HIGHWAYS
- PROVINCIAL AND RURAL ROADS
- CHANGWAT, AMPHOE
- RIVER, RESERVOIR

SUMMARY OF REHABILITATION ROUTES

Route No.	Surface Type	Length (km)	Km Post	ADT (1985) Total	ADT (1985) Heavy Vehicles	A1 Method (7-year period) Section (km)	A1 Method (7-year period) Overlay Cost*	A1 Method (7-year period) Average IRR (%)	A1 Method (7-year period) Average NPV*	DOH Method (7-year period) Section (km)	DOH Method (7-year period) Overlay Cost*	DOH Method (7-year period) Average IRR (%)	DOH Method (7-year period) Average NPV*
RT-224	AC	10	10- 22	3,827	1,693	-	-	-	-	1	512	425.3	9,673
RH- 21	AC	13	120-133	2,235	709	-	-	-	-	-	-	-	-
RH- 22	PM	8	0- 8	2,707	603	-	-	-	-	3	1,088	332.1	5,152
RH- 5	PM	19	20- 39	1,283	468	-	-	-	-	-	-	-	-
RH- 12	DT/ST	10	488-498	1,038	398	6	2,983	106.7	2,295	9	5,475	83.0	1,978
RH- 16	DT/ST	10	7- 12 13- 18	1,475	299	2	569	174.6	2,648	5	2,004	157.5	2,511
RH- 25	DT/ST	10	7- 17	1,206	611	7	2,202	191.0	3,496	7	2,202	191.0	3,496
RH- 27	DT/ST	10	9- 19	813	209	22	3,800	81.2	1,362	10	9,584	41.1	975
Total		90				22	9,554			35	20,865		

Note: *: Thousand baht

CHAPTER 1
INTRODUCTION

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND OF THE STUDY

On the basis of a technical cooperation agreement between the Governments of Thailand and Japan, the Road Development Study in the Northeastern Region (the Phase I Study) was carried out from March 1982 to March 1983.

The Phase I Study comprised the following two main themes:

i) Identification of high priority routes to be developed.

ii) Recommendations for a phased development program based on a pre-feasibility study of the identified routes.

Consequently, a list of priority routes consisting of improvement and new construction routes and rehabilitation routes was prepared, and a phased development program (Stage I and Stage II) was recommended.

The priority routes are summarized as follows:

HIGH PRIORITY ROUTES LISTED IN THE PHASE I STUDY

Type of Route	Stage I		Stage II		Total	
	Number of Routes	Length (km)	Number of Routes	Length (km)	Number of Routes	Length (km)
Improvement and New Construction	18	666.9	15	479.4	33	1,146.3
Rehabilitation	25	468.0	19	306.0	44	774.0
Total	43	1,134.9	34	785.4	77	1,920.3

Note: Stage I : High priority projects
Stage II: Medium priority projects

In compliance with the recommendation of the Phase I Study, the Government of Thailand requested the Government of Japan to carry out a feasibility study of some of the high priority routes listed in the Phase I Study.

In response to the request of the Government of Thailand, the Government of Japan decided to conduct a feasibility study as the Road Development Study in the Northeastern Region Phase II (the Study) and entrusted it to the Japan International Cooperation Agency (JICA).

A study team consisting of 12 experts organized by JICA was dispatched to Thailand for the study from the beginning of July 1984 to the middle of March 1985.

1.2 OBJECTIVES OF THE STUDY

The objectives of the study set forth in the scope of work which was agreed between the Governments of Thailand and Japan were:

i) To carry out feasibility studies of high priority road development projects in the Northeastern Region identified in the Phase I Study.

ii) To perform technology transfer to Thai counterpart personnel in the course of the study.

1.3 SCOPE OF THE STUDY

1.3.1 Improvement and New Construction Routes

Studies on the improvement and new construction routes were carried out for the 15 routes with a total length of 502.1 km listed in Table 1.3.1. (See Figure 1.3.1.)

TABLE 1.3.1 IMPROVEMENT AND NEW CONSTRUCTION ROUTES

Route No.	Origin	Destination	Length (km)
IM - 1	A. Khong	J.R. 2180	46.8
IM - 4	A. Chonnabot	B. Don Han	24.0
IM - 5	A. Nam Phong	B. Nong Tum	28.0
IM - 7	B. Lao (J.R. 210)	B. Tha Yom	40.7
IM - 8	B. Huai Koeng	A. Kumphawapi	14.2
IM - 9	A. Nong Han	A. Kumphawapi	34.3
IM - 12	A. Sawang Daen Din	A. Song Dao	19.1
IM - 19	A. Selaphum	B. Kham Phon Sung	46.3
IM - 24	B. Na Suang	B. Na Yia	13.6
IM - 25	A. Maha Chana Chai	A. Kho Wang	24.5
IM - 26	B. Som Poi Noi	B. Muang Mak	28.4
IM - 27	A. Chom Phra	B. Nong Khawao	31.1
IM - 29	A. Prakhon Chai	A. Krasang	47.1
IM - 31	B. Nong Pha Ong	A. Nong Ki	52.6
IM - 33	A. Si Khiu (J.R. 2)	A. Chok Chai	51.4
Total			502.1

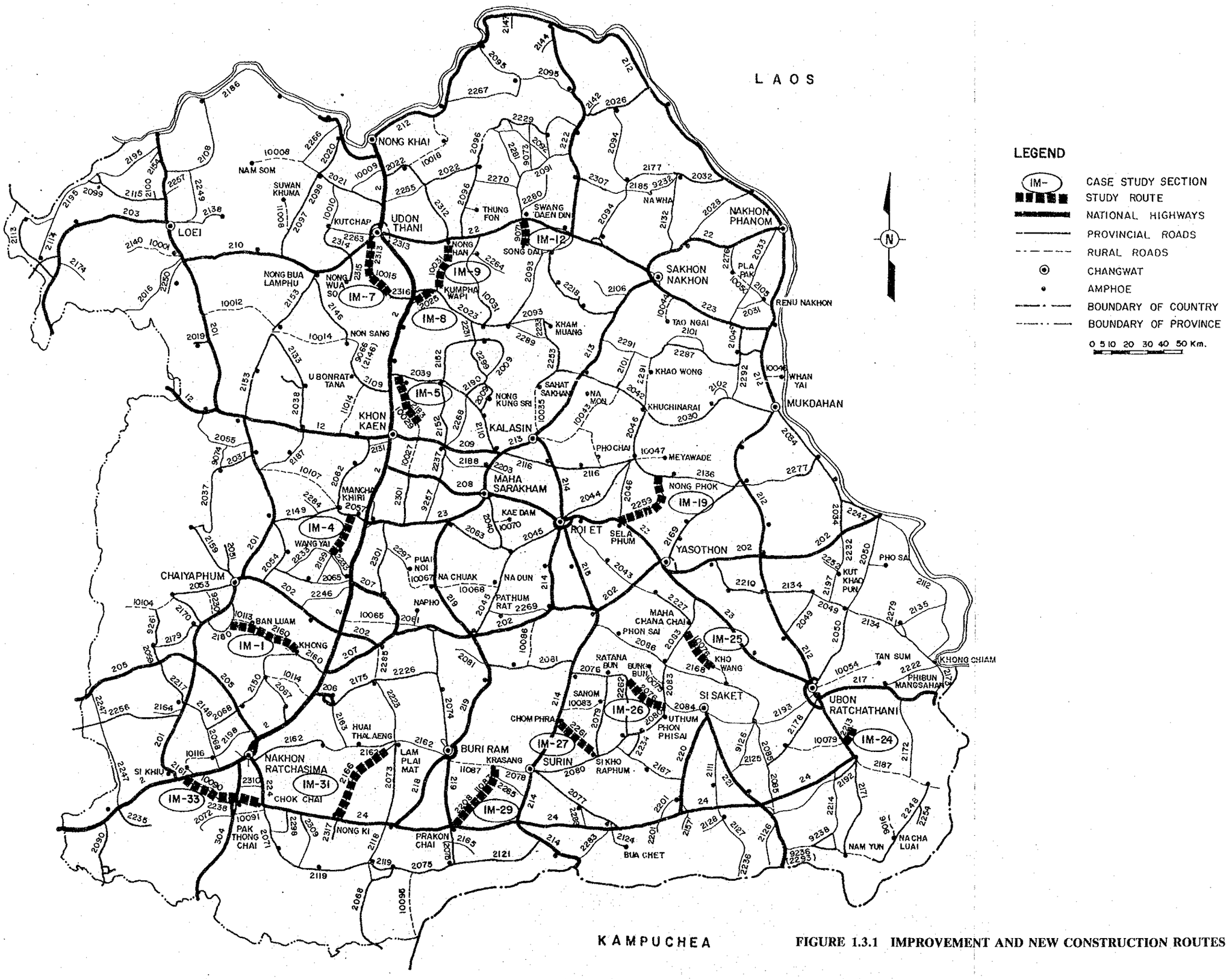


FIGURE 1.3.1 IMPROVEMENT AND NEW CONSTRUCTION ROUTES

1.3.2 Rehabilitation Routes

Studies on rehabilitation were performed for case study sections totalling 90 km on 8 routes set forth in the agreement between the Department of Highways (DOH) and JICA.

The case study sections were decided based on the reconnaissance survey undertaken jointly by DOH and the study team as shown below and in Figure 1.3.2. The reasons why these sections were selected are described in 4.1

CASE STUDY SECTIONS OF REHABILITATION ROUTES

Route No.	Study Section		Surface Type
	Length (km)	Km Post	
RT - 224	10	10 to 20	AC
RH - 21	13	120 to 133	AC
RH - 22	8	0 to 8	PM
RH - 5	19	20 to 39	PM
RH - 12	10	488 to 498	DBST/SBST
RH - 16	10	7 to 12, 13 to 18	" "
RH - 25	10	7 to 17	" "
RH - 27	10	9 to 19	" "
	90		

Note: AC : Asphaltic concrete
PM : Bituminous penetration macadam
DBST : Double bituminous surface treatment
SBST : Single bituminous surface treatment

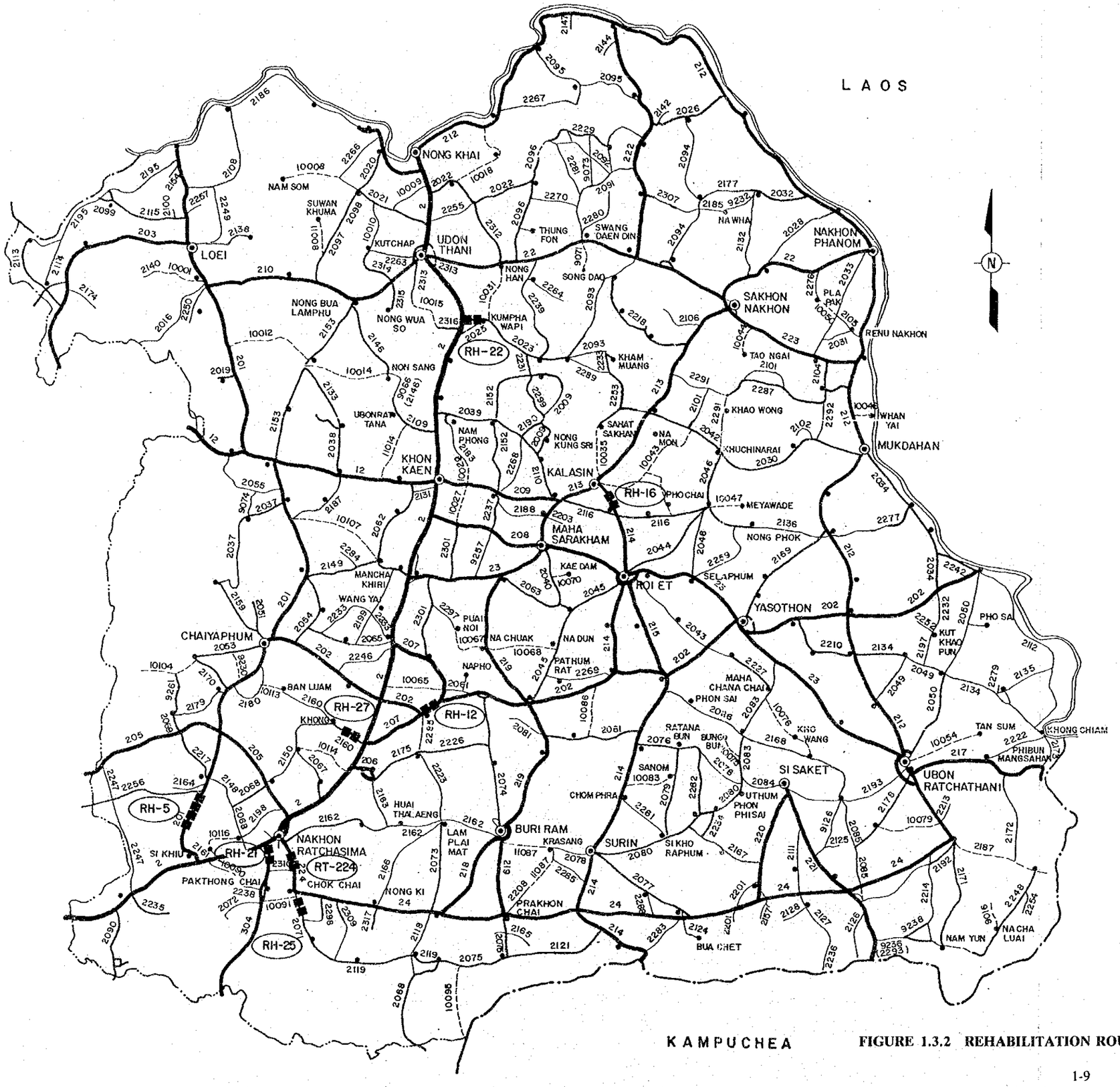


FIGURE 1.3.2 REHABILITATION ROUTES

1.4 STUDY FRAMEWORK

In the scope of work, the following activities were stipulated in order to achieve the objectives of the study:

- Review of the Phase I Study.
- Socio-economic and traffic investigations such as traffic counts, origin/destination (O/D) surveys and home/roadside interviews.
- Engineering investigations such as surveying, soil investigation, construction materials investigation and hydrological investigation.
- Route location study and preliminary engineering design.
- Estimation of construction costs to an accuracy of ± 20%.
- Traffic projection and calculation of benefits.
- Economic evaluation by net present value (NPV), benefit cost ratio (B/C), economic internal rate of return (IRR) and sensitivity testing.
- Optimal phasing for implementation (excluding rehabilitation routes).

In accordance with the study activities specified in the scope of work, a study framework was established as illustrated in Figure 1.4.1.

1.4.1 Improvement and New Construction Routes

The objective of the study on improvement and new construction routes was to evaluate the technical, social and economic feasibility of the study routes.

The feasibility studies for the study routes were carried out in a conventional and practical method. The procedures and methods of the evaluation employed in the study were almost the same as those applied in the Phase I Study except for the level of accuracy employed, because the evaluation in the Phase I Study was carried out at a pre-feasibility study level. In this study it was made at a feasibility study level based on field surveys of a more detailed nature including topographic surveys, boring and soil tests, etc.

The studies performed are briefly explained below by work item.

Influence areas were delineated for each study route for the purpose of defining an area for the projection of population and production affected by improvement of the study route.

Basic socio-economic data were collected and studied for use in economic and social evaluation. Data collection was made in principle at the Amphoe or Tambon level.

The agricultural survey was conducted to obtain information required to forecast future agricultural development and agricultural products such as planted areas, crop yields, farm-

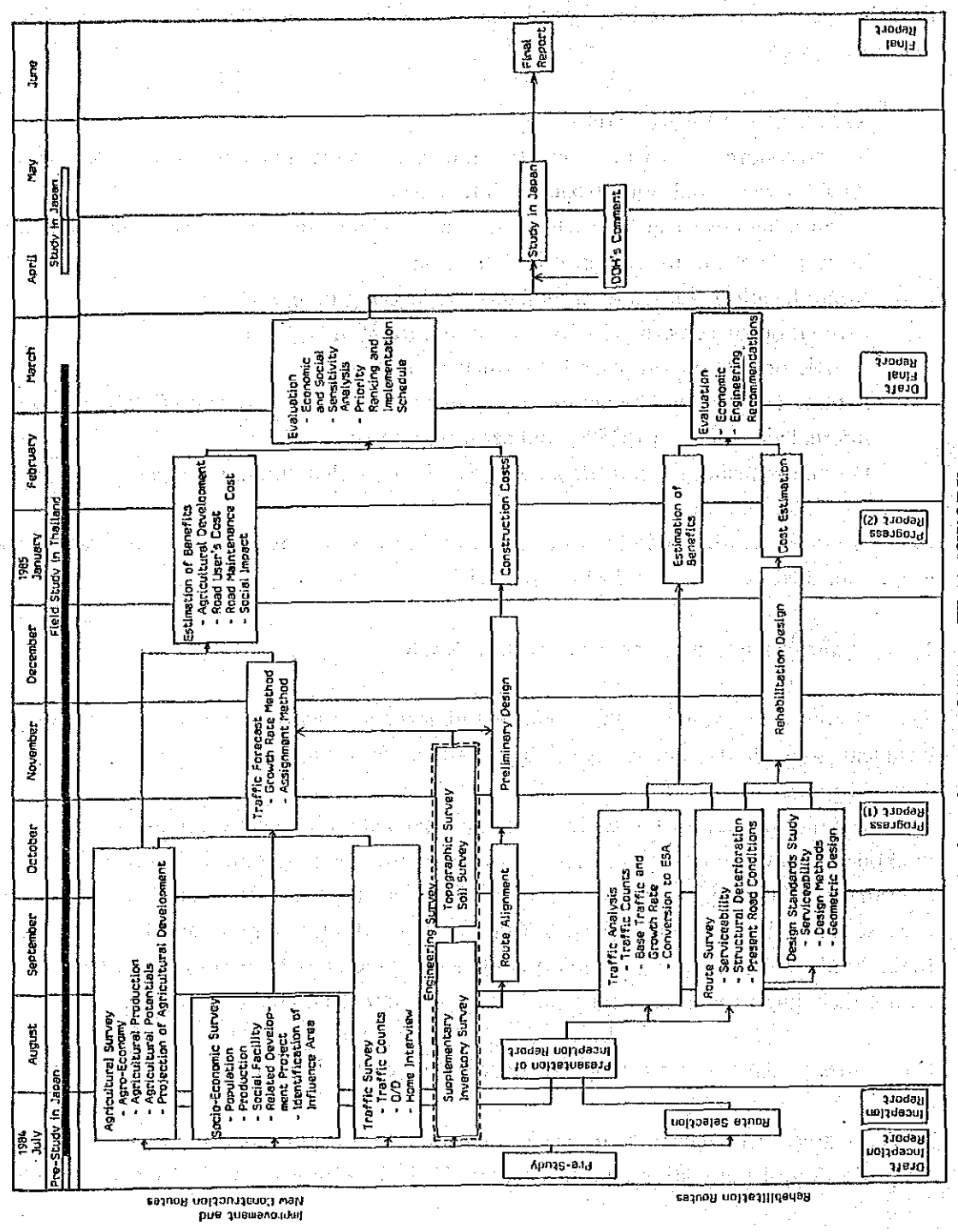


FIGURE 1.4.1 STUDY FRAMEWORK

gate prices and production costs. Forecasts of future agricultural development within the influence area were made for the two cases of "with and without project".

Traffic surveys were carried out mainly aimed at collecting data relevant to the forecast of future traffic volumes and estimation of road user benefits. Origin/destination (O/D) surveys and traffic counts were conducted at 4 and 22 points, respectively, which were carefully selected on or near the study routes. Home interview surveys were carried out mainly aimed at obtaining supporting data for the estimation of income elasticity which was used as a basis to project future traffic growth. Traffic forecasts were given by type of vehicle for the 1st, 7th and 15th years after the opening of the study routes for both "with and without project" cases. Methods employed for the forecasting were either the "Growth Rate Method" or the "Assignment Method", depending on the characteristics of the study routes concerned.

Benefits from the improvement of study routes were quantified by estimating the agricultural development benefit, vehicle operation cost (VOC) savings and road maintenance cost savings for the period of 15 years after opening of the study routes.

In the Phase I Study, an attempt to assess the social impact on the influence areas was made for the following four major criteria: administrative isolation, health services, education services and alleviation of income disparity. In this study a further attempt was made to explicitly quantify the amounts of the four social benefit items.

The study routes were classified in accordance with DOH design standards based on the projected traffic volumes. The results of inventory surveys, topographic surveys, boring and soil tests were fully incorporated into the preliminary design.

The estimation of construction costs was made for each study route, based on the construction quantities and cost data derived from road construction projects which were implemented recently in the Northeastern Region (the Region).

The economic evaluation was made by comparing the estimated construction costs with VOC savings, agricultural development benefits and road maintenance cost savings. As the indices for economic evaluation, IRR supplemented by first year rate of return (FYRR), NPV and B/C were employed. In addition to the above, the study routes were evaluated in terms of magnitude of social impact as well.

Sensitivity to IRR by possible changes in quantified costs and benefits was analyzed assuming a 15% increase in investment costs and a 15% reduction in benefits.

A list of the study routes with priority order in terms of IRR together with ranking by magnitude of social impact was prepared. A comprehensive implementation program corresponding to the resulting priorities and rankings is proposed for the 15 study routes.

1.4.2 Rehabilitation Routes

In the Phase I Study, the identification of the routes to be rehabilitated with a high priority was made for the effective implementation of the road rehabilitation. In this study, however, detailed studies were carried out focusing on clarifying the engineering problems in rehabilitation design and in calculating VOC savings from rehabilitation works as shown in Figure 1.4.1.

The following are brief explanations of the studies performed by item:

The evaluation of the present road surface conditions was carried out by a serviceability survey with visual and physical assessment and roughness measurement. The correlation among the above was separately analyzed by surface type to find the most appropriate and simplified method to assess road surface conditions.

In order to evaluate structural deterioration of existing pavement, deflection surveys, field and laboratory CBR tests and stiffness tests of asphalt concrete were carried out.

Traffic data concerned were analyzed in order to obtain the necessary basic data for overlay and/or reconstruction designs and to estimate benefits from the rehabilitation.

Average equivalent standard 8,200 kg axle loads (ESA) by vehicle type required for overlay design were derived from an analysis of conversion factors of axle loads and gross vehicle weight distribution. The cumulative numbers of ESA were then calculated based on the estimated daily traffic.

The most appropriate design method was examined by a comparative analysis of various design methods being applied in various countries. Preliminary rehabilitation design was carried out in accordance with the design methods selected in the comparative study.

The rehabilitation work quantities were determined by the preliminary design. The unit rates for rehabilitation works were basically derived from the actual unit rates employed in projects recently executed in the Region.

In the estimation of the benefits from rehabilitation works, two cost savings, VOC savings and maintenance cost savings, were considered. VOC savings were carefully studied based on the relationship between roughness and fuel consumption actually measured by the JICA road inspection car.

The economic evaluation was made by comparing VOC savings and road maintenance cost savings with the rehabilitation costs. As the indices for economic evaluation, IRR, NPV and B/C were employed.

The recommendations on engineering aspects such as methodology of pavement assessment and design and practical problems associated with rehabilitation works were presented based on the study results.

1.5 WORK SCHEDULE OF THE STUDY

Field work and studies in Thailand were started at the beginning of July 1984, and were ended in the middle of March 1985 with the submission of the Draft Final Report to DOH. During and after the field work, studies and services in Thailand, the following reports were submitted in accordance with the following conditions stipulated in the scope of the study:

i) Inception Report (30 copies), which included the proposed work program, the methodology and procedures of the study, was submitted at the beginning of August 1984.

ii) Progress Report (I) (30 copies), describing the work performed and a summary of interim findings during the reporting period and the work schedule for the next reporting period, was submitted at the end of October 1984.

iii) Progress Report (II) (30 copies), describing the work done and a summary of interim findings during the reporting period and the work schedule for the next period including the preparation of the Draft Final Report, was submitted at the end of January 1985.

iv) Draft Final Report (30 copies), describing all the work performed during the field work in Thailand, was submitted at the beginning of March 1985. This was prepared considering comments on the progress reports by DOH.

1.6 ORGANIZATION FOR THE STUDY

The study was carried out by a study team under the supervision of the Advisory Committee directed by Mr. H. Morimoto and composed of Japanese Government officials organized by JICA. In carrying out the study, the study team kept close collaboration with the counterpart team organized by DOH. The study team was headed by Mr. M. Tohi and composed of 12 experts from Katahira & Engineers Inc. and Nippon Koei Co., Ltd. The organization for the study is illustrated in Figure 1.6.1.

1.7 REPORTS

The Final Report is organized into the following 3 volumes:

Volume I: Text, which describes the detailed methodologies and analytical pro-

cedures by main study item and summarizes the results.

Volume 2: Appendices, which compile tables and figures of data and information relevant to the study.

Volume 3: Routes, which separately presents a description and evaluation of each study route.

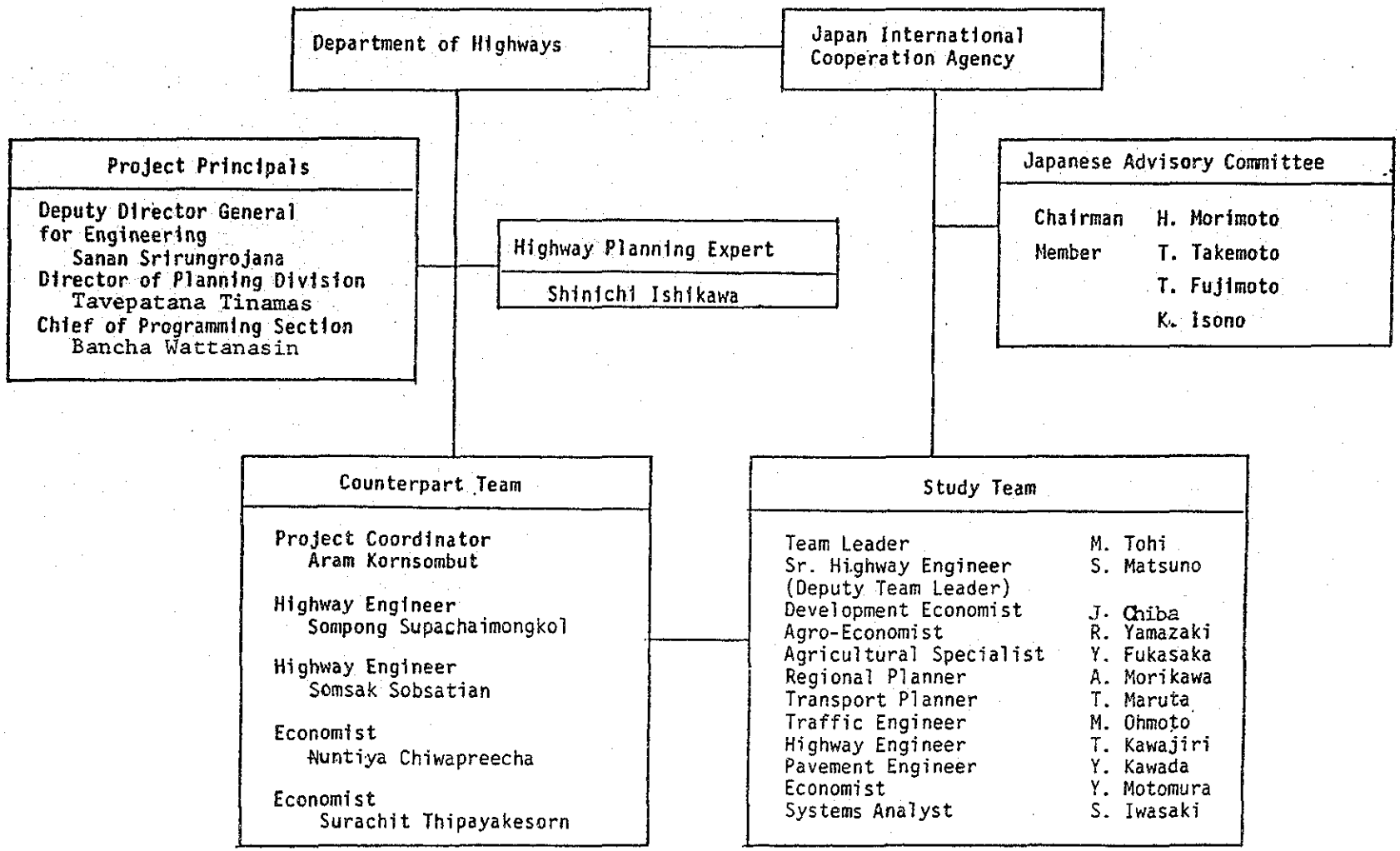


FIGURE 1.6.1 ORGANIZATION FOR THE STUDY

CHAPTER 2

OUTLINE OF THE REGION

CHAPTER 2
OUTLINE OF THE REGION

2.1 LAND AND CLIMATE

The Region, which makes up one third of the population and land area of the Kingdom of Thailand, has remained behind the national average in terms of gross regional product (GRP) and per capita income. In particular, the high rate of designated poverty-striken areas well explains the present economic situation of the Region.

The less-developed economy of the Region has its origin basically in the low productivity in the agricultural sector, the main reasons of which are due to unfavorable soil conditions, insufficient irrigation facilities and uneven precipitation.

A lack of well-connected road systems between agricultural areas and arterial cities where major markets are located is also responsible for the low level of productivity. Development of a road network in the agricultural areas will contribute to raising the living standard of local people in the Region by enabling expeditious transportation of agricultural products to markets and by stimulating increased production.

Thailand as a whole has an area of 514,000 km^2, while the Region has an area of 168,900 km^2, which is roughly equal to 33% of the total area of the Kingdom. The Region lies between 14° and 18° north and 101° and 106° east.

The northern and eastern boundaries of the Region are separated from Laos by the Mekhong River, while its southern boundary touches Kampuchea. The western and southwestern boundaries are adjacent to the North and Central Regions, respectively, of the Kingdom.

Moderate mountain ranges are located only in the west and south boundaries of the Region and considerable numbers of isolated mountains and hills are scattered over the whole area except for the middle part of the Region.

The Mekhong River, forming the boundary between Thailand and Laos with a great number of large and small tributaries, and other rivers to and from lakes and swamps cover the whole

region. These cause repeated flooding. The largest river among them is the Mun River which joins the Mekhong at a point about 80 km to the east of Ubon Ratchatani. The major areas of flooding in the Region are in the Mun basin.

The Khorat Plateau and the Sakhon Nakhon Basin are geologically formed of sedimentary and metamorphic rocks. They are composed of sandstone, shale and siltstone with rock salt and gypsum upon a salt formation together with sandstone, shale, siltstone and modular limestone from the Cretaceous Period and massive sandstone and conglomerate with micaceous shale and siltstone from the Jurassic and Triassic Periods. Deposits of alluvium, eluvium, valleyfill and river gravel from the Quarternary Period to recent times are distributed in band-shapes. The salt formation in the Khorat Plateau is a major drawback to an increase in agricultural productivity.

Igneous rock formations consisting of basalt and similar formations from the Tertiary Period are scattered in the southern part of the Region. Deposits of river gravel as well as basalt and the like are valuable aggregate resources.

The Ratchaburi Formation, consisting of massive limestone interbedded with shale, sandstone, mudstone, conglomerate and volcanic tuff from the Carboniferous and Permian Periods, extends along the west side of the Khorat Plateau and is one of the major sources of crushed aggregates.

In connection with the climate of the Region, the annual mean rainfall is about 1,400 mm with wide differences depending on location, such as 940 mm at Nakhon Ratchasima and 2,240 mm at Nakhon Phanom located on the Mekhong River.

The rainy season in the Region is from May to October, and 85 to 90% of annual rainfall is within the rainy season. The temperature from December to January is comparatively low, with a low of 22°C in January. The temperature in the Mekhong River basin is generally a little lower than that in the southern part of the Region.

2.2 SOCIETY AND ECONOMY

2.2.1 Administration

As a result of an increase of 1 Changwat and 10 Amphoes, the Region had 17 Changwats and 236 Amphoes as of 1983. (See Appendix 2.2.1)

Of these, 11 Changwats and 40 Amphoes are related to the study routes as shown in Table 2.2.1.

Table 2.2.1 CHANGWATS AND AMPHOES RELATED TO STUDY ROUTES

Changwat	Amphoe	Changwat	Amphoe
UDON THANI	M. Udon Thani	CHAIYAPHUM	Chatturat
	Kumphawapi		
	Nong Han	NAKHON RATCHASIMA	Ban Luam
	Nong Saeng		Khong
			Sung Noen
SAKHON NAKHON	Sawang Daen Din		Pak Thong Chai
	Song Dao		Chok Chai
KHON KAEN	M. Khon Kaen	BURI RAM	Krasang
	Nam Phong		Lam Plai Mat
	Kranuan		Nong Ki
	Ban Phai		Prakhon Chai
	Chonnabot		Nong Hong
	Waeng Yai		
		SURIN	M. Surin
ROI ET	Phon Thong		Chom Phra
	Nong Phok		Rattanaburi
	Selaphum		Sikhoraphum
			Prasat
YASOTHON	Sai Mun		
	Kut Chum	SI SA KET	Rasi Salai
	Maha Chana Chai		Yang Chum Noi
	Kho Wang		Uthumphon Phisai
			Bung Boon
UBON RATCHATHANI	Det Udom		

2.2.2 Population

Thailand had a total population of 49,515,000 or 96 persons per square km as of 1983. The average annual growth rate during the period 1979-1983 was 1.8%, and the population in 1983 was 7% higher than in 1979. The Region had a total population of 17,219,000 (35% of the Kingdom's total) or 102 persons per square km with an average annual growth rate of 2.2% in the same period. In terms of population density, the Region ranks second after the Central Region, excluding Bangkok. Population by region in 1979 and 1983 and projected growth rates covering the study period are shown in the following table:

POPULATION AND GROWTH RATE BY REGION 1980-2005

Region	Year-end Population[1] (1000 persons)		Density in 1983	Growth Rate (% per annum)				
	1979	1983	(person/km^2)	1980-85	85-90	90-95	95-2000	2000-05
Whole Kingdom	46,114	49,515	96	2.0	1.5	1.5	1.4	1.2
Northeastern	15,793	17,219	102	2.0	1.4	1.3	1.2	1.1
Central	10,112	11,005	108	1.8	1.5	1.5	1.4	1.4
Northern	9,493	10,106	59	1.5	1.1	1.1	1.0	1.0
Southern	5,716	6,166	87	1.9	1.4	1.3	1.2	1.1
Bangkok	4,999	5,018	3,206	3.4	2.7	2.6	2.4	2.2

Sources: 1. Department of Local Administration, Ministry of Interior.
2. "Population Projection for Thailand, Whole Kingdom and Region, 1970-2005" by Working Group on Population Projections, National Statistics Office (NSO).

Population by Changwat in the Region during the period 1979-1983 is shown in Table 2.2.2. With regard to the population of the Changwats related to the study routes, Nakhon Ratchasima had the largest population (2,055,000), followed by Ubon Ratchathani (1,684,000) and Udon Thani (1,564,000). In terms of population growth rate, the figures for the southeastern part of the Region, such as Surin, Buri Ram and Ubon Ratchathani, are higher than those in other parts of the Region.

2.2.3 Gross Regional Product

In 1982, the amount of gross domestic product (GDP) reached 858 billion baht or 17,702 baht per capita at the current market price. Average annual growth rates of GDP and per capita GDP during the period 1978-1982 were 5.6% and 3.3%, respectively.

Although the Region makes up 35% of the total population, it accounts for only 14% of GDP due to the Region's low overall productivity, and per capita gross regional product (GRP) of the Region is the lowest among the 4 Regions and Bangkok Metropolis. Shares of GDP and per capita GRP by region are shown below:

SHARE OF GDP AND PER CAPITA GRP BY REGION

	Share of GDP (%)			Per Capita GRP (at CMP*)		
	1960	1970	1979	1960	1970	1979
Whole Kingdom	100	100	100	2,160	3,848	12,067
Northeastern	17.0	16.0	14.7	1,082	1,822	4,991
Central (excl. Bangkok)	29.3	27.5	31.2	2,565	4,662	17,655
Northern	15.8	15.2	14.9	1,496	2,699	8,781
Southern	14.1	12.8	11.8	2,700	3,858	12,683
Bangkok	23.8	28.5	27.4	5,630	10,234	30,161

Note : *: Current market price
Source: The Fifth National Economic and Social Development Plan (1982-1986)

In terms of gross provincial product (GPP) of related Changwats, Nakhon Ratchasima's GPP is 7,800 million baht, one of the highest in the Region with an average annual growth rate of 5.4%, followed by Udon Thani with 4,800 million baht. Although the highest per capita GPP in the Region is 3,800 baht in Nakhon Ratchasima, this is only half the average per capita GDP in the whole Kingdom. (See Tables 2.2.3 and 2.2.4)

TABLE 2.2.2 POPULATION BY CHANGWAT

(Unit: thousand persons)

Changwat	1979	1980	1981	1982	1983	Average Annual Growth Rate (%)	Remark
Loei	441	450	463	473	487	2.5	
Udon Thani	1,429	1,448	1,475	1,508	1,564	2.3	*
Nong Khai	661	674	689	730	737	2.8	
Sakhon Nakhon	766	777	789	807	821	1.8	*
Nakhon Phanom	-	-	-	541	567	(4.9)	
Khon Kaen	1,329	1,355	1,385	1,416	1,463	2.4	*
Maha Sarakham	752	765	771	780	807	1.8	
Kalasin	742	755	772	785	793	1.7	
Roi Et	1,044	1,061	1,075	1,089	1,118	1.7	*
Yasothon	452	459	464	470	475	1.3	*
Ubon Ratchathani	1,531	1,560	1,590	1,628	1,684	2.4	*
Chaiyaphum	839	858	871	885	903	1.8	*
Nakhon Ratchasima	1,886	1,917	1,950	1,980	2,055	2.2	*
Buri Ram	1,108	1,133	1,160	1,187	1,227	2.6	*
Surin	1,001	1,036	1,065	1,079	1,121	2.9	*
Si Sa Ket	1,066	1,082	1,103	1,120	1,151	1.9	*
Mukdahan	-	-	-	243	248	(2.2)	*
Whole Kingdom	46,114	46,962	47,875	48,847	49,515	1.8	
Northeastern Region	15,793	16,088	16,393	16,720	17,219	2.2	

Note : *: Changwats related to the study routes
Source: Department of Local Administration, Ministry of Interior

2.2.4 Poverty Conditions

In the Region, 172 Amphoes were identified as poverty Amphoes by the National Economic and Social Development Board (NESDB). Of these, 151 Amphoes were identified in the "Rural Poverty Eradication Program 1979" Report and 21 Amphoes were added in the 1981 Report. In the Reports, poverty conditions were identified by the following poverty index:

CLASSIFICATION OF POVERTY

Classification	Poverty Index
High Poverty	More than 80
Medium Poverty	60 - 80
Low Poverty	Less than 60

Source: NESDB

Since the 1981 Report, the identification and classification of the poverty conditions of 10 newly established King Amphoes has not yet been done. As a result, those Amphoes are temporarily classified in the same poverty categories with the Amphoes from which they were separated.

The poverty Amphoes in the Region classified by NESDB are shown below and in Appendix 2.2.2.

POVERTY AMPHOES

Classification	Number of Amphoes
High Poverty	77
Medium Poverty	99
Low Poverty	60
Total	236

Source: NESDB

TABLE 2.2.3 GPP OF RELATED CHANGWATS

(Million baht at 1972 constant price)

Changwat	1978	1979	1980	1981	1982	Average Growth (1978-1982) %
Udon Thani	3,341.1	3,479.7	3,897.2	4,492.3	4,808.8	9.5
Sakhon Nakhon	1,508.5	1,906.8	2,039.7	2,122.9	2,123.4	8.9
Khon Kaen	3,494.4	4,086.5	4,286.0	4,288.7	4,552.8	6.8
Roi Et	2,017.6	2,434.1	2,378.5	2,506.1	2,419.4	4.6
Yasothon	1,003.1	1,056.9	1,151.5	1,122.7	1,111.5	2.6
Ubon Ratchathani	2,928.0	3,425.0	3,979.9	4,169.5	4,184.3	9.3
Chaiyaphum	1,970.6	2,051.7	2,213.5	2,044.0	2,282.5	3.7
Nakhon Ratchasima	6,343.6	6,674.2	7,509.9	7,504.4	7,816.1	5.4
Buri Ram	2,799.7	2,630.3	2,867.8	2,265.9	2,566.7	-2.1
Surin	2,168.5	2.133.1	2,292.9	2,466.1	2,377.9	2.3
Si Sa Ket	1,802.4	2,183.6	2,363.0	2,478.7	2,363.3	7.0
Northeastern (GRP)	37,205.0	40,385.0	43,902.7	44,653.0	45,599.7	5.2
Whole Kingdom (GDP)	261,097	276,907	292,853	311,270	324,290	5.6

Source: NESDB

TABLE 2.2.4 PER CAPITA GPP OF RELATED CHANGWATS

(Baht at 1972 constant price)

Changwat	1978	1979	1980	1981	1982	Average Growth (1978-1982) %
Udon Thani	2,350	2,392	2,627	2,971	3,112	7.3
Sakhon Nakhon	1,971	2,442	2,566	2,621	2,568	6.8
Khon Kaen	2,642	3,009	3,098	3,027	3,138	4.4
Roi Et	1,917	2,278	2,191	2,268	2,158	3.0
Yasothon	2,214	2,294	2,453	2,352	2,296	0.9
Ubon Ratchathani	1,928	2,199	2,496	2,559	2,510	6.8
Chaiyaphum	2,356	2,395	2,530	2,286	2,509	1.6
Nakhon Ratchasima	3,371	3,474	3,872	3,752	3,839	3.3
Buri Ram	2,546	2,334	2,482	1,911	2,111	-4.6
Surin	2,175	2,094	2,184	2,270	2,141	-0.4
Si Sa Ket	1,698	2,010	2,133	2,193	2,052	4.8
Northeastern (per capita GRD)	2,366	2,511	2,671	2,658	2,658	2.9
Whole Kingdom (per capita GDP)	5,873	6,092	6,304	6,554	6,688	3.3

Source: NESDB

2.3 TRANSPORTATION

The major transportation modes in the Region consist of highways, railways and aviation, while inland navigation is minor. Each transportation mode has been developed in such a manner to connect every part of the Region with Bangkok through the two arterial axes of Bangkok-Udon Thani and Bangkok-Ubon Ratchathani.

The transportation system of the Region is briefly described below.

2.3.1 Highways

The arterial highway network in the Region is formed by 5 primary highways and 23 secondary highways. Route 2 originates at Saraburi branching off from Route 1 from Bangkok and extends to Nong Khai via Nakhon Ratchasima, Khon Kaen and Ubon Ratchathani. Route 24, which connects Nakhon Ratchasima with Ubon Ratchatani, passes through the southern part of the Region. These two primary highways have vital importance as the main highway arteries in the Region. The other primary highways, Routes 12, 22 and 23, which traverse the Region east and west from Route 2, also constitute the spokes of the highway network.

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

In the Region, national and provincial roads owned by DOH make up about 1,600 km of primary highways, 3,200 km of secondary highways and 7,600 km of provincial roads. The road networks under DOH in the Region are shown in Appendix 2.2.3 and kilometerage by district is given in Appendix 2.2.4.

2.3.2 Railways

The State Railway of Thailand (SRT), owned by the Government, has a railway system radiating out from Bangkok, with a total route length of 3,735 km as of the end of fiscal 1982.

In the Region, two railway lines extend from Bangkok to Nong Khai and to Ubon Ratchathani after branching at Nakhon Ratchasima. The Bangkok-Nong Khai route is 624 km in length and runs via Khon Kaen and Udon Thani. The Bangkok-Ubon Ratchathani route stretches 575 km in length through Buri Ram, Surin and Si Sa Ket. Daily passenger trains run 6 and 4 times on the routes between Bangkok-Ubon Ratchathani and Bangkok-Nong Khai, respectively.

Among the study routes, part of IM-1 parallels the railway between Non Ta Noen in Chaiyaphum and Ban Luam in Nakhon Ratchasima. Passenger trains run only 3 times a

day on this route.

2.3.3 Aviation

Thai Airways, owned by the Government, operates scheduled services on routes radiating out from Bangkok to all over the country. In the Region, daily flights on the Bangkok-Udon Thani route via Khon Kaen and the Bangkok-Ubon Ratchathani route also via Khon Kaen are in operation employing Boeing 737-200s.

2.4 AGRICULTURE

2.4.1 Farm Population

Agriculture and related industries are the dominant economic sector in the Region as well as in the other regions of Thailand. Of the Region's population, 82%, or about 14.1 million in 1983, is in the farming sector. This is about 42% of the total farm population of the whole country. The average growth rate of the Region's farm population for the past three years (1981-1983) was 1.5% as shown below. This low rate, compared to 2.5% for the total population, implies that farmers in low productivity areas have a tendency to migrate to Muangs or other regions.

FARM AND NON-FARM POPULATION

	Farm		Non-Farm		Total	
	(thousand)	(%)	(thousand)	(%)	(thousand)	(%)
Northeastern Region						
1981	13,680	(84)	2,713	(16)	16,393	(100)
1982	13,885	(83)	2,835	(17)	16,720	(100)
1983	14,093	(82)	3,126	(18)	17,219	(100)
Growth, 81-83	1.5% p.a.				2.5% p.a.	
Whole Country						
1981	32,500	(68)	15,375	(32)	47,875	(100)
1982	33,085	(68)	15,762	(32)	48,847	(100)
1983	33,681	(68)	15,834	(32)	49,515	(100)
Growth, 81-83	1.8% p.a.				1.7% p.a.	

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

Details of farm and non-farm population by Changwat are given in Appendix 2.4.1.

2.4.2 Natural Conditions and Land Use

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

On the other hand, many areas in the river basins of the Mekhong, Chi and Mun, where drainage systems are insufficient, are often flooded in the rainy season.

Forest land in the Region was estimated at 16.9 million rai in 1981, which accounts for only 16% of the Region's total land as shown in Table 2.4.1. This percentage is the smallest among the regions of the country, the average ratio of which is 31%. On the other hand, farm land in the Region makes up 49% of the total, which is the highest in the country, compared to a 38% average nationwide. The growth of cultivated areas in the Region has been slowing because of limitations on the remaining cultivable land, which is mainly forest land.

The cultivated areas in the Region are mainly planted with paddy (70%), upland crops (21%) and tree crops, vegetables and flowers (1%), as shown in Table 2.4.1.

Details of agricultural land use by Changwat are given in Appendix 2.4.2 and the land capability map of the Region is attached in Appendix 2.4.3.

TABLE 2.4.1 AGRICULTURAL LAND USE

(Unit: thousand rai)

	Forest Land A	Farm Land Total B	Paddy C	Upland Crops D	Tree Crops, Vegetables, and Flowers E
Northeastern Region (1)					
Total Land: 105,534					
(T_1) (100)	(A/T_1)	(B/T_1)	(C/B)	(D/B)	(E/B)
1975	28,824 (27)	47,497 (45)	34,090 (72)	7,527 (16)	548 (1)
1978	19,513	49,301	35,555	9,257	542
1981	16,941 (16)	51,708 (49)	36,183 (70)	10,736 (21)	623 (1)
Growth 75 - 78	- 12.2%	1.3%	1.4%	7.1%	-0.4%
75 - 81	- 8.5%	1.4%	1.0%	6.1%	2.2%
Whole Country (2)					
Total Land: 320,697					
(T_2) (100)	(A/T_2)	(B/T_2)	(C/B)	(D/B)	(E/B)
1975	130,762 (41)	112,211 (35)	71,239 (63)	19,953 (18)	10,771 (10)
1978	109,515	116,441	73,270	23,759	10,772
1981	100,582 (31)	121,294 (38)	73,523 (61)	27,385 (23)	11, 712 (10)
Growth 75 - 78	- 5.7%	1.2%	0.9%	6.0%	0%
75 - 81	- 4.3%	1.3%	0.5%	5.4%	1.5%
Ratio					
(T_1) / (T_2) 1981		42.6 %	49.2 %	39.2 %	5.3 %

Source: OAE, MAC

Cultivated lands in the Region mainly extend along the river basins of the Mekhong, Mun and Chi. Soil conditions in the existing cultivated areas have been deteriorating since necessary measures for soil conservation and land improvement have not been sufficiently taken. One of the factors against soil productivity in old paddy fields is salinity. In a 1977 study[1], areas with a total of 5,283,000 rai (8,453 km^2) were counted as affected by excessive salinity of over 8 mmho/cm (5,120 ppm). This is around 15% of the total paddy field area in the Region. These lands cannot be improved unless a large scale leaching system is introduced. Salinity areas can be widely found over the paddy fields in Udon Thani, Roi Et, Chaiyaphum, Nakhon Ratchasima and Buri Ram among the related Changwats in this study. A soil salinity distribution map is attached in Appendix 2.4.4.

Source: 1. Study of Salinity Affection in 1977, Department of Land Development.

In view of geographical features, water resources and land use for crop production, the related Changwats were classified into the following:

Paddy Area (mainly flat lands and the river basins of the Mekhong, Chi and Mun - the share of paddy areas is more than 80% of the cultivated area in the area):

Sakhon Nakhon, Roi Et, Yasothon, Ubon Ratchathani, Buri Ram, Si Sa Ket and Surin.

Paddy and Upland Crop Area (mainly flat lands including low hillsides between 200-300 m - the share of paddy and upland crop areas are around 60% and 30%, respectively, of the total cultivated area):

Udon Thani, Khon Kaen and east part of Chaiyaphum.

Upland Crop Area (hillsides over 300 m and mountainous areas - upland crops are planted in more than 60% of the total cultivated area):

Nakhon Ratchasima and west part of Chaiyaphum. Maize and cassava grow mainly in Nakhon Ratchasima.

Geographical features and other general features of land use are illustrated in Figures 2.4.1 and 2.4.2, and planted areas by crop type at Changwat level in 1983-84 are given in Appendix 2.4.5. Trends in planted area for a period of 11 years from 1973 are shown in Appendix 2.4.6.

2.4.3 Irrigation

Twelve departments under 6 ministries are undertaking the implementation of water resource development projects and projects concerned with irrigation to promote village development. However, major irrigation projects in the Region are conducted by the Royal Irrigation Department (RID).

The total irrigated area in the Region under RID projects was 404,000 ha (2,527,000 rai) in 1981 as shown in Table 2.4.2.

Irrigated areas are concentrated in the basins of the Mun, Chi and Mekhong Rivers represented by the Song Khram basin. More than 70% of irrigable areas in the Region have already been developed, and future irrigation projects will be implemented mainly in the basins of the Mun and Chi. Even after implementation of possible irrigation projects in these basins, the total irrigable area in the Region will be only around 7% of the total cultivated area, or 10% of the total paddy area.

Distribution of irrigation projects is shown in Appendix 2.4.7.

2.4.4 Production of Major Crops

In terms of planted area, paddy field ranked first in the Region followed by cassava, maize, kenaf, sugarcane, groundnuts, cotton, mungbeans, soybeans and sorghum in a recent three year average (1981–83) as shown in Table 2.4.3. The percentage of planted area for paddy, cassava and kenaf in the Region as part of the national total was 47, 59, and 100, respectively.

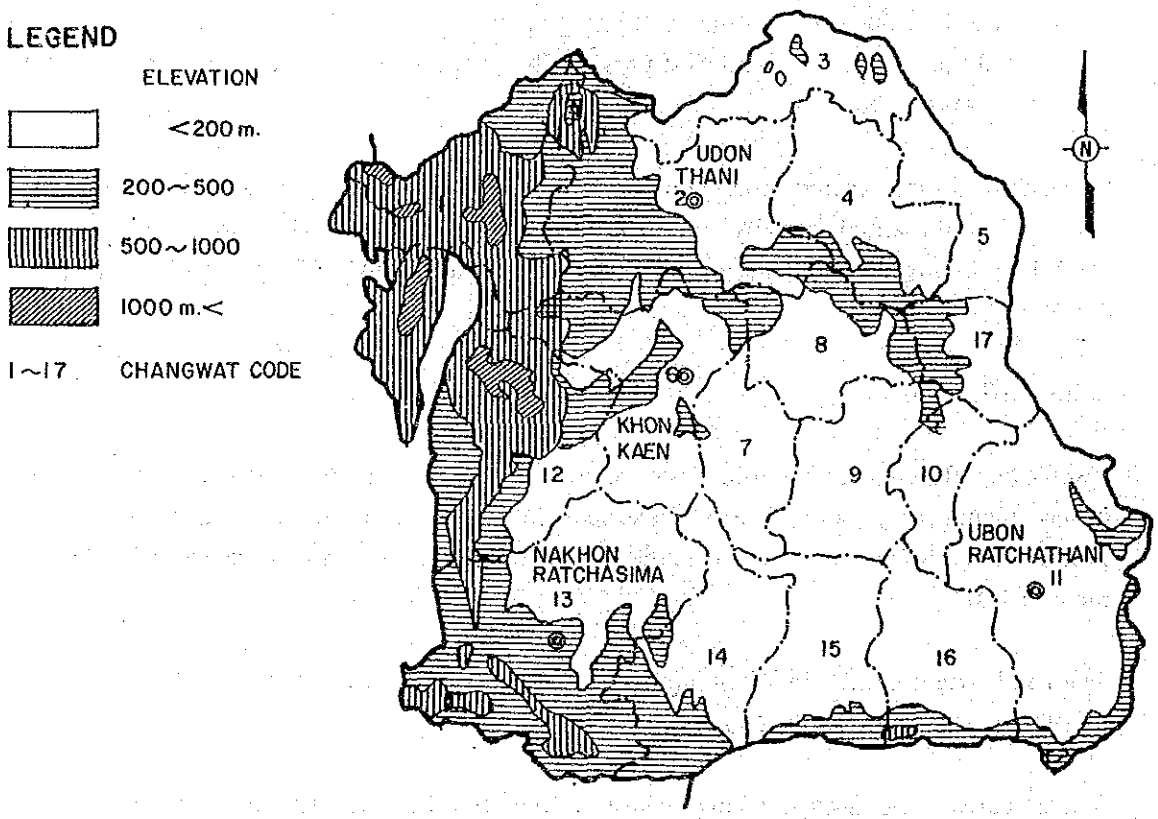


FIGURE 2.4.1 GEOGRAPHICAL FEATURES

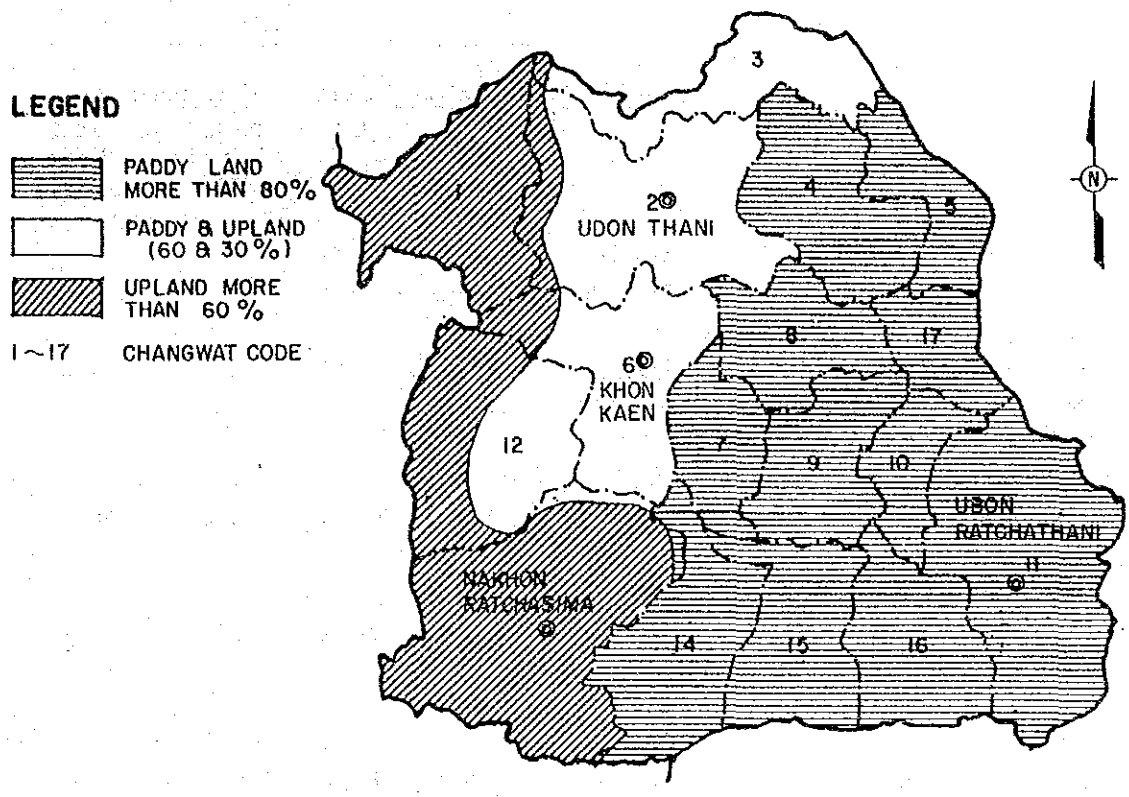


FIGURE 2.4.2 GENERAL FEATURES OF LAND USE

TABLE 2.4.2 IRRIGATION PROJECTS IN NORTHEASTERN REGION UNDER THE ROYAL IRRIGATION DEPARTMENT (1981)

(Unit: ha (rai))

	Irrigable Area	Irrigated Area (%)	% of Irrigable Area to Total Cultivated Area	% of Irrigable Area to Total Paddy Area
By District				
Khon Kaen Regional Office (Loei, Udon Thani, Khon Kaen, Maha Sarakham)	113,676 (710,475)	92,732 (81.6) (579,575)	4.6	7.3
Ubon Ratchathani Regional Office (Sakhon Nakhon, Nakhon Phanom, Ubon Ratchathani, Kalasin, Roi Et, Yasothon)	219,739 (1,373,369)	168,539 (76.7) (1,053,369)	8.4	11.0
Nakhon Ratchasima Regional Office (Chaiyaphum, Nakhon Ratchasima, Buri Ram, Surin, Si Sa Ket)	228,713 (1,429,457)	142,997 (62.5) (893,732)	7.2	10.4
Total	562,128 (3,513,301)	404,268 (71.9) (2,526,676)	6.9	9.8
By Basin				
Mekhong River Basin	112,853 (705,331)	98,583 (87.4) (616,144)	-	-
(Song Khram Basin only)	52,867 (330,419)	49,441 (93.5) (309,006)	-	-
Chi River Basin	199,954 (1,249,713)	138,850 (69.4) (867,813)	-	-
Mun River Basin	249,321 (1,558,257)	166,835 (66.9) (1,042,719)	-	-
Total	562,128 (3,513,301)	404,268 (71.9) (2,526,676)	-	-

Source: Water Resources Development in Thailand, Royal Irrigation Department, MAC.

TABLE 2.4.3 PLANTED AREA AND PRODUCTION (1981-83 AVERAGE)

Crops	Whole Country			Northeastern Region		
	Planted Area (1000 rai)	Production (1000 tons)	Average Yield (kg/rai)	Planted Area (1000 rai)	Production (1000 tons)	Average Yield (kg/rai)
Rice	60,712	17,794	293	28,392	5,948	209
Maize	10,281	3,334	324	3,002	892	297
Mungbeans	3,032	284	94	124	11.3	91
Soybeans	861	141	164	58	9.2	159
Groundnuts	769	146	190	173	29.6	171
Cassava	8,149	18,506	2,271	4,794	10,442	2,178
Sugarcane	3,707	26,159	7,064	514	3,358	6,537
Kenaf	1,289	216	168	1,285	209	163
Cotton	773	139	180	170	33.4	196
Sorghum	1,646	279	170	56	9.7	173

Source: Agricultural Statistics of Thailand, OAE, MAC.

Crop productivity in the Region is comparatively low because of the factors mentioned in sections 2.4.2 and 2.4.3, such as uneven water supply and poor soil conditions. Except for cotton and sorghum, the average yields of crops are lower than the national average. In particular, the yield of paddy in the Region, where about 60% of the paddy land is planted with glutinous rice, is only 71% that of the national average. Rice production in the Region is mostly under rainfed conditions.

Plowing of paddy fields is carried out when the first or second heavy rain falls in April or May, usually followed by transplanting in June or July and harvesting in November or December. Local glutinous varieties with early-maturing properties are harvested in the period from mid-October to early November.

In spite of the factors mentioned above, the production of upland crops such as cassava, sugarcane, cotton and beans has been increasing rapidly for the past 8 years, possibly due to the improvement of the road network in the Region. However, kenaf production has decreased because of a decline in market demand. Yet kenaf is still one of the major commercial crops and its related industry is important to the Region. The same is true for cassava and sugarcane. Sericulture is also a typical agro-industry in the Region, though production is not large.

Past production trends show that the production of major crops in the Region increased in relation to the rate of the expansion of planted area except for groundnuts and kenaf.

Detailed data on past production are shown in Appendix 2.4.8 and trends in average yield of crops by Changwat are given in Appendix 2.4.9.

Cassava production in Thailand, mainly dependent on the market in the European Economic Community (EEC), has exceeded demand in recent years due to the expansion of planted areas and increased productivity.

MAC formulated the Crop Diversification Program at the end of July 1984 by which cassava plantations will be diversified to other cash crops, such as sorghum, mungbeans and eucalyptus. The Program, however, will be a trial plan for a few years in a limited area of the major cassava producing areas in the Region.

2.4.5 Agro-Industries and Marketing

An interview survey concerning agro-industries showed that the collection and transport of raw materials to factories is carried out as shown below:

TRANSPORTATION OF RAW MATERIALS

	Transport by		(%)
Crop	Farmer	Factory	Middleman
Sugarcane	100	-	-
Cassava	82	5	13
Rice	37	13	50
Kenaf	13	69	18

Almost all sugarcane and more than 80% of cassava are transported to factories by farmers in their own or hired trucks. While half of paddy is still dealt with by middlemen, kenaf is mainly collected by the factories themselves.

The number of agro-industry processing factories in the Region are as follows:

NUMBER OF PROCESSING FACTORIES

Rice mills (capacity: more than 30 t/day)	132
Cassava plants (chips, pellets, flour)	297
Kenaf plants (baling, textile)	95
Sugar plants (brown, refinery sugar)	13

Large and medium scale rice mills are mainly located in Changwat centers and in urbanized Amphoes in the rice producing areas.

Most of the cassava processing plants are located along Routes 2, 24, and 304 in Nakhon Ratchasima and Khon Kaen. Some small scale cassava chip plants are located along the provincial roads near cassava producing areas. Cassava chips are mainly transported to large scale pellet or flour plants to be processed, and then the processed materials are transported directly to exporters in Bangkok or to factories in Chonburi and Chacheongsao mainly by Routes 2 and 304, or sometimes by rail.

Kenaf plants are mainly located in Changwat centers such as Udon Thani, Khon Kaen, Ubon Ratchathani and Nakhon Ratchasima.

Large scale sugar plants with processing capacities of more than 2,200 tons/day of sugarcane are in Udon Thani, Khon Kaen and Buri Ram. Two sugar plants at Kumphawapi in Udon Thani and at Nam Phong in Khon Kaen have large capacities of more than 5,000 tons/day and each collected more than 7 million tons of sugarcane during the 6 or 7 months from November to May in the 1983 crop year.

Since the content of the harvested sugarcane usually decreases by 5–10% per day, an improvement in accessibility from sugarcane fields to sugar plants is very important.

The number and total production of processing facilities in related Changwats are shown in Appendix 2.4.10. Commodity flows of main crops around related Amphoes are given in Appendix 2.4.11.

2.5 REGIONAL DEVELOPMENT

During the period of the First to Fifth National Economic and Social Development Plans (NESDP), changes in Thailand's socio-economic structure have brought significant benefits to society, particularly by expanding manufacturing and service activities in most urban areas and, in particular, in Bangkok Metropolis. However, there are still many people in rural areas who have not benefited from past development efforts and who have barely been able to participate in these economic changes.

The regional economic structure still largely depends on agriculture since industrial and service activities have not yet been widely spread to the regions. This has caused widened economic and income gaps between rural and urban inhabitants and also among regions.

To solve the above socio-economic problems, the Fifth Plan (1982–1986) mainly puts stress on the following development objectives:

- Restoration of the country's economic and financial position
- Adjustment of economic structures and raising of economic efficiency
- Development of social structures and distribution of social services

- Poverty alleviation and development of backward rural areas
- Coordination of economic development activities with the national security management
- Reformation of the national development administration system and deconcentration of the land-holding pattern

In order to improve agricultural productivity, the Fifth Plan puts emphasis on 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 the growth of agro-based industries and to an increase in employment opportunities.

The Fifth Plan lays down a development strategy of the employment of the diffusion and decentralization of the economic activities to the regions. In this effort, the establishment of regional urban growth centers is being promoted. In the Region, the cities of Khon Kaen and Nakhon Ratchasima are designated as regional urban growth centers. Linkages between the regional urban centers and the lower-order centers are necessary to spread favorable economic effects to the rural areas. The Fifth Plan has designated Ubon Ratchathani, Roi Et and Surin as lower-order centers, because their basic infrastructural facilities and social services are still inadequate and low in quality. They are particularly short of water drainage systems, flood prevention schemes, sewage and waste disposal systems, potable water supplies, telephone services and traffic management, which are all vital to the economic promotion required for lower-order centers.

According to "Business Review" (September 1979), the Government designated Promotional Investment Zones for General Industries and Location of Industrial Estates. Amphoes M. Nakhon Ratchasima, Pak Thong Chai and Pak Chong in Nakhon Ratchasima, and Amphoes M. Khon Kaen and Ban Phai in Khon Kaen have been included in this designation.

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

One of the Fifth Plan's major objectives is to develop backward rural areas in order to make it possible for the people in the areas to help themselves. It is aimed at lifting poor rural people out of absolute poverty and allowing them to expect improvements in their living standards in the long run. To achieve poverty alleviation, the Government has designated "target areas" for rural development during the Fifth Plan period, covering 216 districts and 30 subdistricts in the Northeast, North and South Regions. A number of projects will be implemented in the Region including village fishery projects, village water resource projects, district hospital projects, basic health services projects, soil improvement projects and saline soil development projects.