KINGDOM OF THAILAND

MINISTRY OF COMMUNICATIONS
DEPARTMENT OF HIGHWAYS

FEASIBILITY STUDY
FOR
NONG BUA - BAN LAM CHI BON HIGHWAY PROJECT

FINAL REPORT

FEBRUARY 1980

VOLUME 1 : TEXT

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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PREFACE

In response to the request of the Government of the Royal Kingdom of Thailand, the Government of Japan has decided to take up a feasibility study on the Project of Nong Bua-Ban Lam Chi Bon Highway linking the north-western region with the north-eastern region of Thailand, and the Japan International Cooperation Agency (JICA) conducted the study.

Noting that the Nong Bua-Ban Lam Chi Bon Highway Project has a vital bearing on the development, economic interrelationship and the future road transportation system in this area, the JICA dispatched a preliminary survey team to Thailand in July, 1978 for preparation of the feasibility study, and sent, from June 10 to September, 1979, another 4-member supervisory group headed by Mr. Shigeki Uchiyama, Director of the Yokohama National Road Construction Office, Ministry of Construction as well as a 8-member study team headed by Mr. Masahiko Tohi.

The Study was carried out smoothly as scheduled over a period of about three months with the close co-operation of the competent Thai authorities. After its return to Japan, the teams made further studies and analyses and compiled this report.

I sincerely hope that this study would be found useful for the socio-economic development of the region and serve for the promotion of the friendly relations now existing between our two countries.

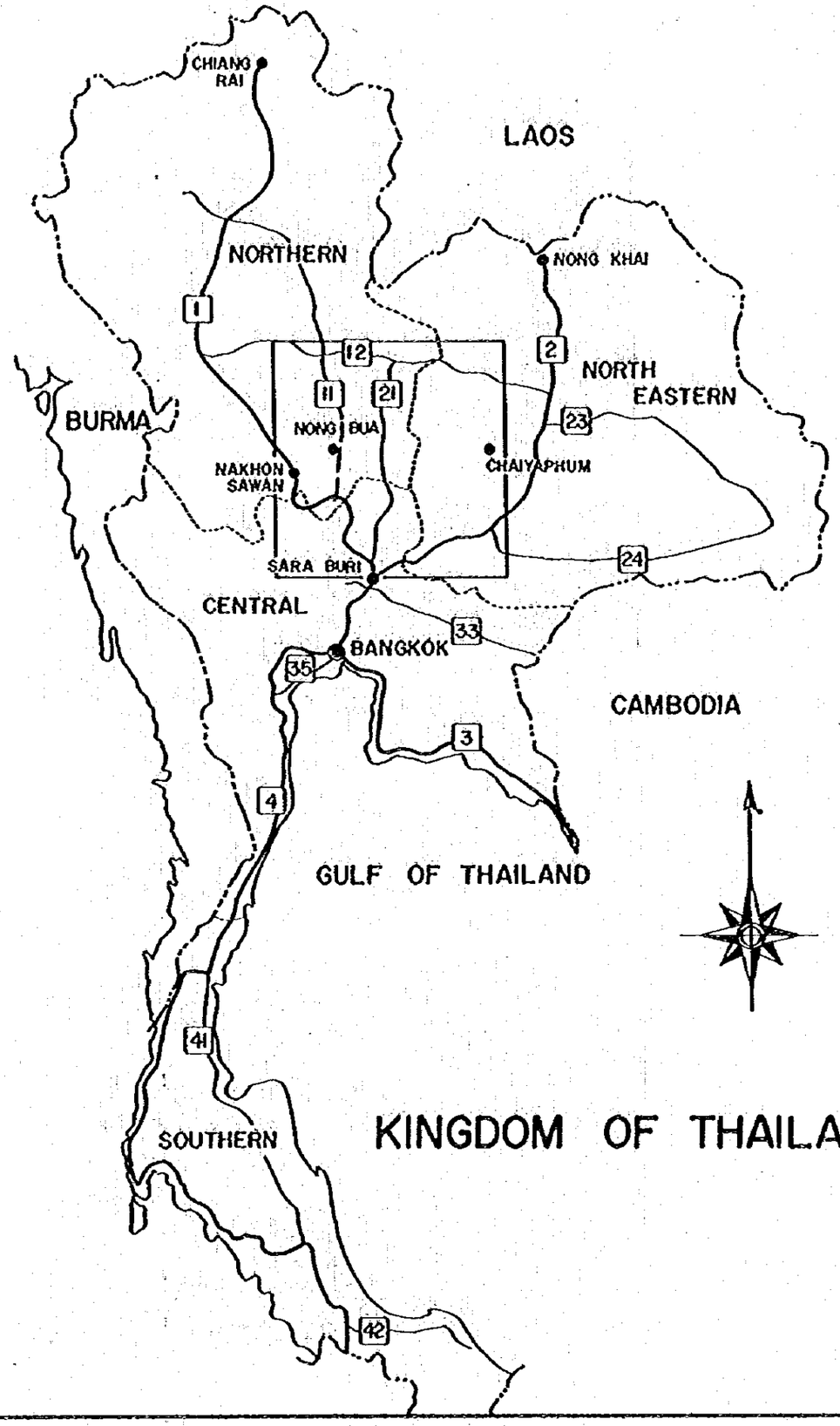
I wish to express my deep appreciation to the competent authorities and officials concerned of Thailand for their valuable assistance offered to the team throughout the survey period.

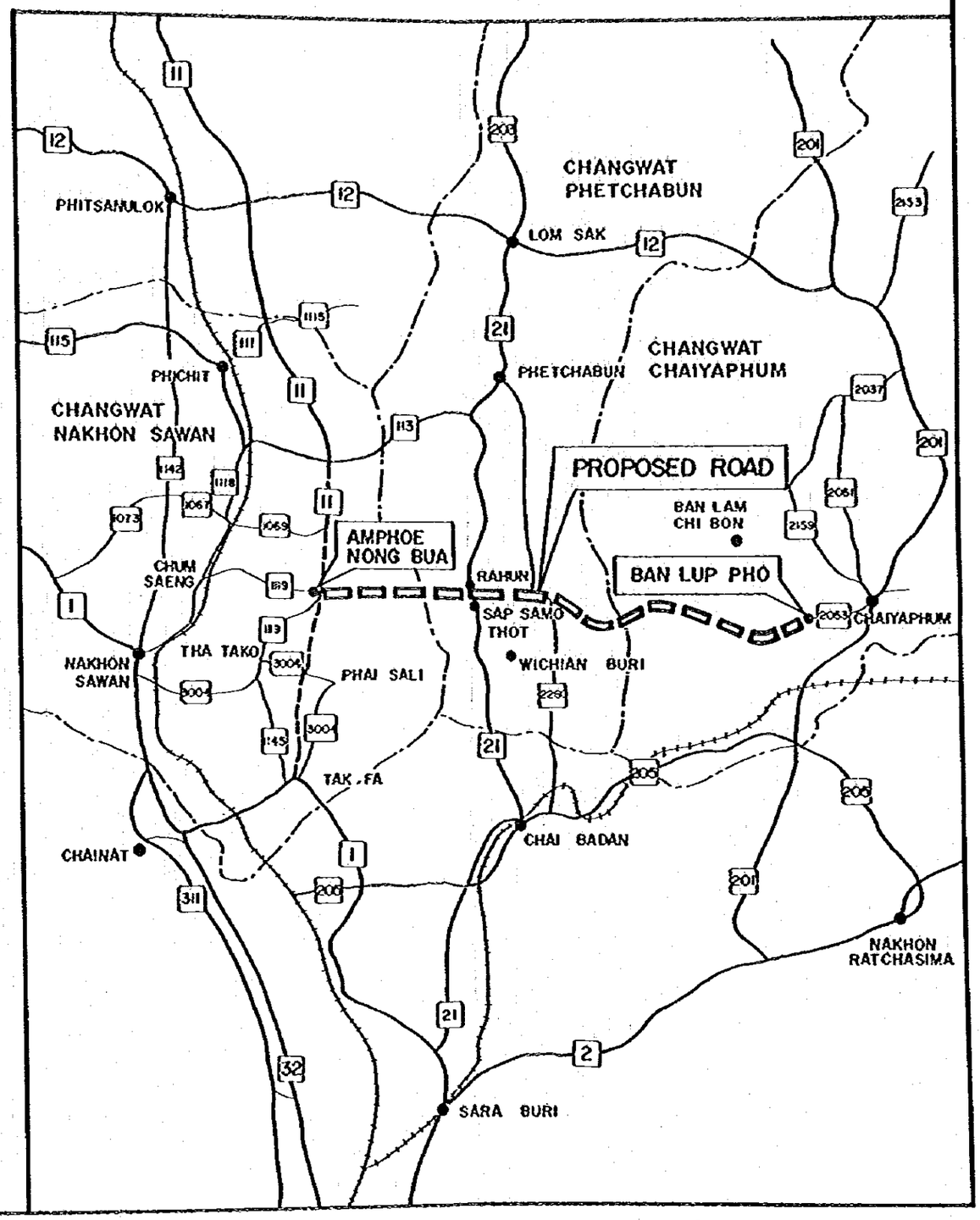
February, 1980

Keisuke Arita

Keisuke Arita
President
Japan International
Cooperation Agency

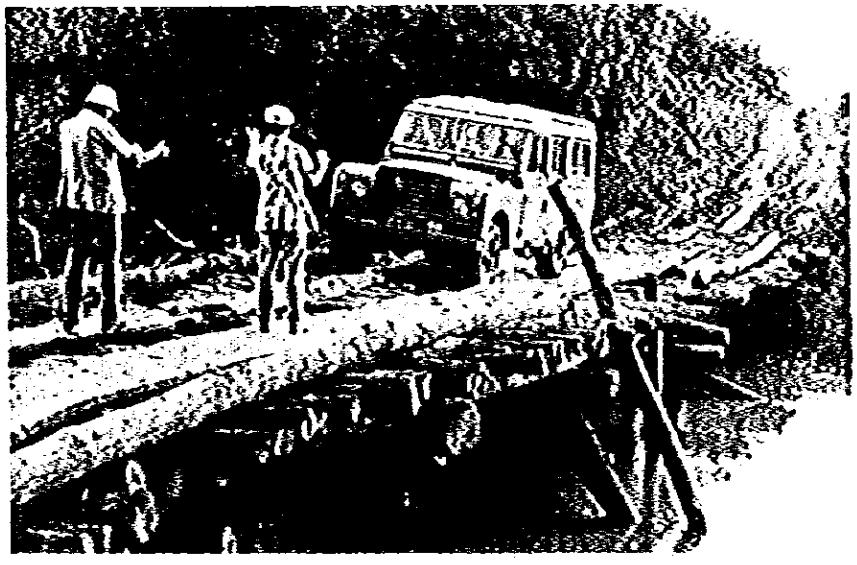
PROJECT LOCATION





SOIL AGGREGATE ROAD IN MAIZE AREA

EARTH SURFACED ROAD IN POOR CONDITION



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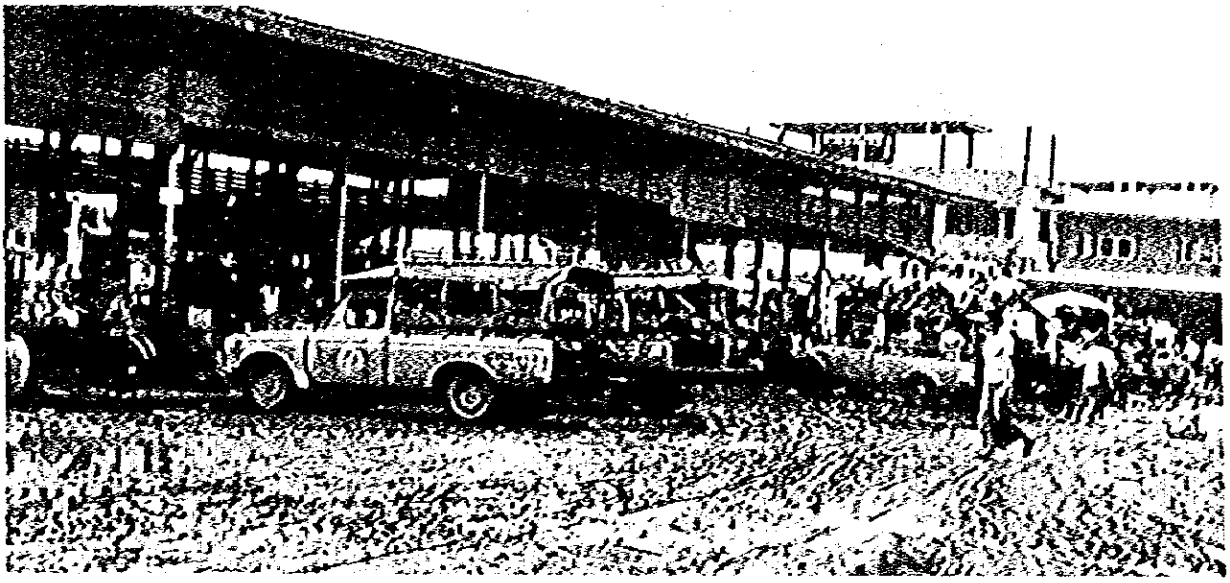
CHAO RIVER NEAR NA RAYA

LIGHT BUS, MOST POPULAR VEHICLE
IN THE PROJECT AREA



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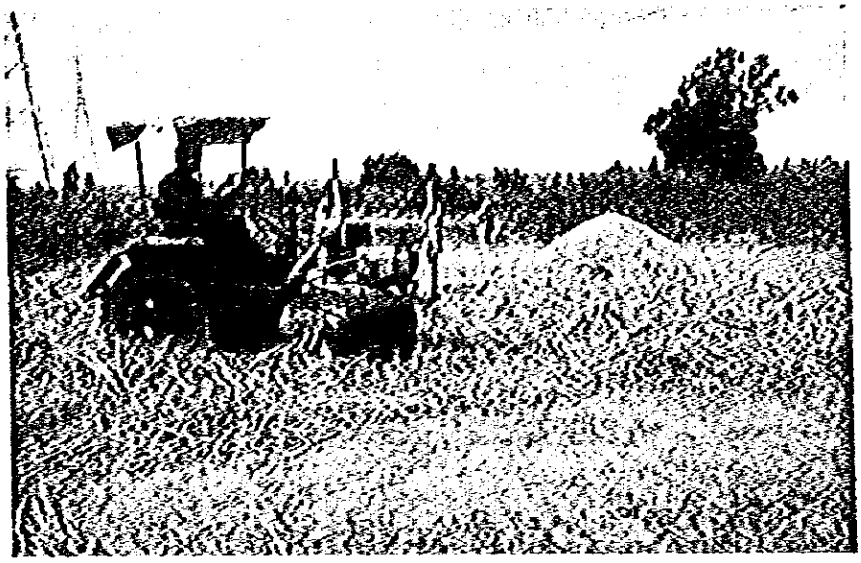
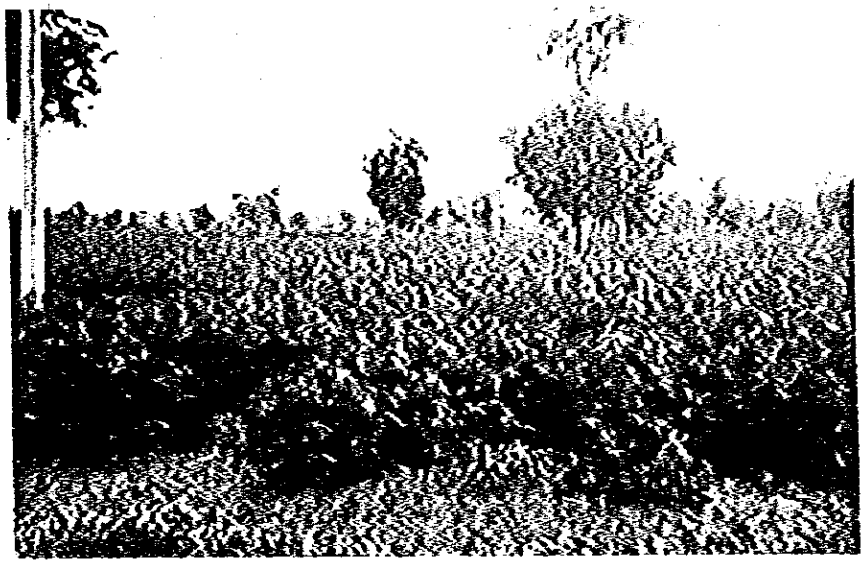
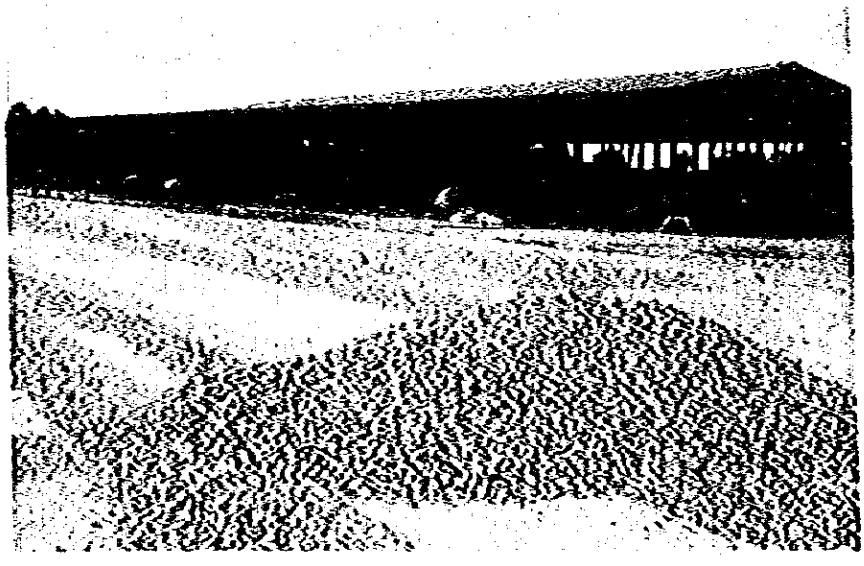


RICE THRESHING BY TRACTOR



CASSAVA FARM IN THE PROJECT AREA



LOCAL CASSAVA AND KENAF FACTORY

NONG BUA-BAN LAM CHI BON HIGHWAY PROJECT FINAL REPORT

VOLUME 1 TEXT

SUMMARY CONTENTS

SUMMARY AND RECOMMENDATIONS

SUMMARY AND RECOMMENDATIONS

1. Kingdom of Thailand, with about 44 million of population and an area of 514,000 square kilometers, involves a problem of disparities between urban area especially Bangkok and rural areas. For the mitigation of the disparities, the development of rural economies especially agricultural productivity and the enhancement of economic exchanges among rural areas are the major strategic requirements. In the Fourth National Economic and Social Development Plan (1977-1981), a particular attention is paid to the expansion and decentralization of public utilities, transportation and communication services, aiming at the reduction of regional imbalance. For the recovery of the agricultural production in the rural area and the reduction of regional imbalance between Bangkok area and the remaining areas, the improvement of regional road networks will play a critical role.

2. Road networks of the country comprise 12,856 km of national highways, 9,942 km of provincial roads and 14,000 km of incomplete provincial roads. Only about 4,900 km of provincial roads are paved. In the said National Development Plan, the Royal Government allocates 73 percent of the budget for the transportation sector to the road investment, putting emphasis on the improvement of secondary and provincial roads to accelerate the agricultural development in

rural areas and to supplement the regional trunk road networks. Complying with the national strategy, the Department of Highways (DOH) of the Ministry of Communications is contemplating to expand about 8,500 km of additional secondary and provincial road networks by the target year of its Plan for Provincial Road Construction and Improvement (1977-1981).

3. The proposed Nong Bua-Sap Samo Thot-Ban Lam Chi Bon Highway Project is a part of the above-mentioned government program and is listed up as Route No. 2184 in the above Five Year Plan. The Project aims at accelerating socio-economic development in rural areas and, at the same time, at providing an inter-provincial road, in an east-west direction, to supplement the existing highway network which are mainly of radial type connection with Bangkok.

4. The Project area includes parts of three Changwats (provinces) of Nakhon Sawan, Phetchabun and Chaiyaphum and relates with ten Amphoes (districts) of them. The area of influence extends over 160 km from east to west with a width of 30-40 km and is of about 2 million rai of land. The population of the area is estimated at about 277,000 in 1979.

5. In and surrounding the Area, highways in a north-south direction are relatively dense. In the area widely bounded by Route 1 in the western end and Route 2 in the eastern end, roads running also vertically include Route 21 in the center, Route 201 in the east and Route 11 under construction in the west. In addition, two proposed provincial roads, Route 1142 and Route 2260, will complete the north-south road network. On the other hand, network of east-west highways is not well developed. There exist only Route 12 in the north and Route 205 in the south apart about 160 km each other. Such being the situation, the proposed east-west inter-provincial road will play a vital role for completeness of the well-balanced road network of the Area.

6. The existing roads in the Area, except Route 21 and some of provincial highways, are earth or laterite surfaced and suffer more or less from damages by floods in rainy season. Some of them are of good conditioned enough, especially in dry season, to enable local trips in fairly long distance. In the area, bus is the most popular transportation mode of passenger traffic. In the Nakhon Sawan/Phetchabun part the main type is light bus, while heavy bus has the big share in the Chaiyaphum part.

7. Agriculture sustains entirely the economy of the Area. Paddy is a major crop common in the Area. Besides, maize provides the biggest crop production in the Nakhon Sawan/Phetchabun part, while cassava and kenaf are the important crops in the Chaiyaphum part. About 75 percent of rice produced in the Area is consumed within the area and the residual is shipped outside. Almost 100 percent of upland crops, produced mostly for export, is sent out of the Area through assembling markets along national highways. Major assembly markets for maize are established along Route 21, while markets for cassava and kenaf are located mainly in the Chaiyaphum part.

8. Prior to the route selection, a slight modification was made for the project location, according to the discussions with the DOH. Despite the original name of the Project, i.e. Nong Bua - Sap Samo Thot - Lam Chi Bon Dam Highway, it was judged that the terminus is to be changed to Lup Pho instead of Lam Chi Bon Dam. The dam site is not suitable point for the terminus, as the long delay of the proposed Chi Irrigation Scheme is anticipated. Moreover, the east-west highway is not completed unless the route be connected to Lup Pho village, the end point of the paved Route 2053 which leads to Chaiyaphum. Hence, Lup Pho was selected as the terminus of the Project on the Chaiyaphum side. An intersection point with Route 21 might be considered at Sap Samo Thot as in the original plan. In addition, Rahun 5 km north of Sap Samo Thot was judged d to be considered as an alternative point since it is well located having a road running to the east from it.

9. In selecting route alternatives, special attention was paid to the following major controlling factors: i) to avoid the proposed reservoir areas of the Chi Irrigation Project and ii) to select the lowest portions crossing over the mountain ranges, especially two ranges between Changwats Phetchabun and Chaiyaphum. Other additional factors to be taken into account included: to search a straight connection as possible, to utilize the existing road alignments and permanent concrete bridges, to pass the potential areas for the agricultural development as much as possible and to connect many villages as possible.

10. Route alternatives were examined dividing the conceived corridor into three parts: Part I (Nong Bua - Wang Wat), Part II (Wang Wat - Tha Pong) and Part III (Tha Pong - Lup Pho). Part II has no route alternative, since the alignment is decisively limited by the possible crossing of two mountain ranges, the Luak Range and the Phang Hoei Range. For Part I, as a result of sectional comparison, the following two major alternatives were conceived:

Route Alternative I-1; via Nong Ngu Luam, one of the biggest bus terminals between Nong Bua and Sap Samo Thot, and crossing Route 21 at Rahun.

Route Alternative I-2; via Wang Phikun, one of the biggest villages and assembly markets in the Part I area, and crossing Route 21 at the southern part of Sap Samo Thot.

Part III has the following two alternatives depending on the crossing point of the Chi River:

Route Alternative III-1; crossing over the Chi River at the proposed dam site and then following the alignment of the existing irrigation road.

Route Alternative III-2; passing the Chi at the site of the bridge under construction near Nong Bua Rawe

11. Evaluation of the alternatives was made in comparison mainly of the following three factors: i) construction cost, ii) route length which reflects on the road users' costs and iii) availability of newly cultivable land along the route which reflects the magnitude of agricultural benefits. Based on the analysis including preliminary design of each alternative, the elements to be compared were obtained as follows:

Alternatives	Length /1 (km)	Const. Cost (mil. B)	New Land (1,000 rai)
Part I			
Route Alt. I-1 (Nong Bua - Nong Ngu Luam - Rahun - Sap Bon - Wang Wat)	70.3 /2	112.7	97.3
Route Alt. I-2 (Nong Bua - Wang Phikun - Sap Samo Thot south) - Wang Wat)	80.3	128.9	116.2
Part II			
No Route Alternative	41.7	-	-
Part III			
Route Alt. III-1 (Tha Pong - Upper Chi Dam site - Lup Pho)	56.0	77.0	93.9
Route Alt. III-2 (Tha Pong - Nong Bua Rawe - Lup Pho)	43.7	47.3	94.1

Note : /1 These figures are the lengths tentatively defined only for the comparative study of route alternatives.

/2 Excluding the length of 5.3 km which is overlapped with the Phetchabun - Chai Badan Highway Project.

As a result of comparative analysis, Route, Alternative I-1 was selected for Part I and Route Alternative III-2 was found far preferable to III-1. Thus, the optimum route, for which agricultural development projection, traffic forecast and detailed engineering studies were to be made, was selected as follows:

Optimum Route: Nong Bua - Nong Ngu Luam - Rahun - Sap Bon - Wang Wat - Tha Pong - Nong Bua Rawe - Lup Pho.

12. It was forecasted that the accelerated agricultural development would be accrued by the Project mostly in the band area of 5 km wide on both sides of the optimum route selected. In this area, it was estimated that 286,000 rai of uncultivated land is available for future development. Major effects of the proposed road to the agricultural development taken into account in the study include: acceleration of rate of opening of new land, increase of farmgate prices, increase of crop yield by the improved farming. Agricultural development benefits attributable to the Project is counted by increment of net added value of production derived from these effects.

13. Corresponding to two roles of the project road, role for local transportation services and role as an inter-regional trunk highway, two types of traffic were conceived; local traffic and through traffic. Local traffic was forecasted dividing into passenger traffic and freight traffic. Estimation of passenger traffic was based on the projected population and the person trip rate model derived from the home interview survey. Freight traffic was forecasted further dividing into the traffic for transportation of agricultural products and other freight traffic correlated with the passenger movement. Through traffic was forecasted based on the estimated rates of diversion from the surrounding highways, which were obtained from O/D survey and bus passenger interview survey on the surrounding highways. The projected total traffic in 1990, 7th year after opening, shows that road links of over 300 ADT reach 64 percent of total length.

14. In accordance with the DOH's design standard, based on the forecasted traffic, preliminary design was made and the project cost was estimated. The main technical features of the Project are summarized below.

Road length*:		
Improvement	41.9	km
New Construction	112.8	km
Total	154.7	km
Road width:		
Formation width	9.0 - 10.0	m
Pavement width (SBST)	5.5 - 6.0	m
Surface Treatment:		
SBST	105.0 km	(68%)
Soil aggregate surface	49.7 km	(32%)
Main Construction Works:		
Earthwork		
Cleaning and grubbing	560	ha
Soil and rock excavation	1,220,610	m^3
Embankment	1,349,130	m^3
Pavement		
Selected fill	282,850	m^3
Subbase and shoulder	291,940	m^3
Base	106,650	m^3
Prime and SBST	604,860	m^2
Drainage structures		
Box culvert	253	m
Pipe culvert	3,829	m
Bridges	777	m

* Note : 1) The length was determined after detailed engineering study for optimum route, and thus one kilometer shorter than the total length employed in the comparative study of route alternatives.
2) The length excludes the portion between Nong Daeng and Sap Bon, 5.3 km, which is overlapped with the proposed Phetchabun - Chai Badan Highway Project.

15. The estimated project costs, expressed in mid-1979 price and in million Baht, are summarized as follows:

	Local	Foreign	Total
Direct Construction Cost	203.3	175.6	378.9
Engineering and Administration	10.3	20.0	30.3
Land Acquisition	11.9	-	11.9
Physical Contingency	30.5	26.3	56.8
Price Contingency	89.0	45.5	134.5
Total	345.0	267.4	612.4

The foreign component amounts at US$13.4 million or 44 percent of the total project costs.

16. For the economic evaluation, economic construction costs were estimated, by deducting transfer items from financial costs, at 431.3 million Baht. Recurrent expense for road maintenance is estimated at around 5.2 million Baht per annum. In 7th year after opening, an overlay cost of 50.7 million Baht will be required.

17. Major benefits accrued from the Project are savings of road users' costs, composed of vehicle operating costs and occupants' time cost, and increment of net added value of agricultural production attributable to the road improvement. They were estimated as follows:

	1984	1990	1998
Road Users' Cost Savings (million Baht)	113.6	130.7	161.6
Agricultural Development Benefit (million Baht)	1.2	58.8	55.4

18. The economic internal rate of return (EIRR) of the Project was estimated at 21.7 percent, which indicates that the Project is economically viable. A sensitivity test made under a pessimistic case, 20 percent cost increase and 20 percent benefit decrease, showed that the EIRR would fall to 14.5 percent but the Project is still justifiable economically. Although 32 percent of total length is assigned for soil aggregate surface according to the Standard, it is desirable, from an engineering viewpoint, to pave all the mountainous section. Viability was also examined for a case that the whole length would be paved. The results showed that the total project costs increased to 652.6 million Baht and the economic internal rate of return fell to 20.7 percent. It was revealed that the Project would be still justifiable even if the whole length is paved. An analysis of the optimum timing of the Project showed that a postponement of one year would not be justifiable. Furthermore, a sectional evaluation for the stretch of F5 standard, including the mountain crossing section, indicated that this section itself would be justifiable economically having EIRR of 12.7 percent. Thus, the Project is recommended to be implemented as a whole as early as possible.

19. The Project will have a considerable impact to the regional development providing an east-west trunk highway connecting three Changwats. To activate the inter-provincial economic exchange, the more direct and efficient connection by the Project will be the indispensable requirement. At present, no road exists crossing over the mountain ranges between Phetchabun and Chaiyaphum. The construction of a new road in this section is of special importance to complete the effective road network in the region, although the construction costs for this section is very costly despite a small traffic volume forecasted. Viewing the importance of the Project to the improvement of the inter-regional network, it is recommendable to designate the Project road a secondary national highway.

20. As the Project is technically sound, economically viable and socially desirable, it is worthy of taking necessary actions toward its early implementation. It is recommendable to arrange promptly with agencies concerned for financing the project implementation including detailed design works to be started with.

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GLOSSARY

AASHO	:	American Association of State Highway Officials
ARD	:	Accelerated Rural Development Office
ADT	:	Average Daily Traffic
Amphoe	:	District
B	:	Baht (Thai unit of currency)
Changwat	:	Province
DOH	:	Department of Highways
GPP	:	Gross Provincial Product
IBRD	:	International Bank for Reconstruction and Development
IRR	:	Internal Rate of Return
rai	:	Unit of area (0.16 hectare)
RID	:	Royal Irrigation Department
RMC	:	Road Maintenance Cost
SBST	:	Single Bituminous Surface Treatment
Tambon	:	Sub-District

Chapter 1

INTRODUCTION

Chapter I

INTRODUCTION

1-1 FACTORS LEADING TO THE STUDY

One of the main objectives of the Fourth National Economic and Social Development Plan (1977-1981) is to redress the regional balance and to raise up income level and living standard of the people in the rural areas. To attain this objective, the Plan sets up the strategy to decentralize such basic infrastructures as roads, water supply, sewerage and drainage facilities to the rural areas, where the development of such infrastructures is far behind the level of urban areas. Among them, the roads have a role of paramount importance to strengthen the production bases of the economic sectors, especially that of the agricultural sector. Therefore, the Plan is putting emphasis on the construction of provincial roads and rural roads reaching the remote areas.

In the past development of road networks in Thailand, attention was paid to the construction and improvement of radial trunk highways with Bangkok as the center to cater for the majority of passengers and goods movements which are to and from Bangkok reflecting its dominant position in the economy of Thailand. However, in the present circumstances where most of such radial type highways have completed, the trunk highways which link these radial trunk highways each other are needed to realize more efficient and denser road networks as a whole.

The general project area covers Changwat Nakhon Sawan and Phetchabun in the southeastern part of the Northern Region and Changwat Chaiyaphum in the southwestern part of the Northeastern Region (the location is shown

in the attached "PROJECT LOCATION"). The area is widely surrounded by National Highways, Route 1 in the West, Route 201 in the East, Route 12 in the North and Route 205 in the South. In the center of the area, Route 21 leading to Bangkok runs in a north-south direction and a provincial road of Route 2260 in parallel with Route 21, connecting Phetchabun and Chai Badan, is proposed for immediate implementation. In addition, in the western part of the area, Route 11, also a north-south highway, is now under construction. However, except for the short highway of Route 113 in the northwestern part which connects Route 11 and 21, the area has no trunk highway in an east-west direction to link three Changwats, between the existing east-west highways of Route 12 and 205, which are more than 160 km apart each other. Especially, two Changwats of Phetchabun and Chaiyaphum have no direct connection, despite the fact that they are geographically adjacent, due to the steep mountain ranges which separate both Changwats. Accordingly, the present journey between these two Changwats both of passengers and goods, is by way of Lomsak using Route 12 or by way of Lam Narai using Route 205.

Under such background, the Department of Highways (hereinafter referred to as the DOH) of the Ministry of Communications of the Royal Government of Thailand listed up the road construction between Nong Bua in Changwat Nakhon Sawan and Ban Lam Chi Bon in Changwat Chaiyaphum as Route 2184 (hereinafter referred to as the Project) with high priority in its Plan for Provincial Road Construction and Improvement (1977-1981).

> It should be noted that the project location was slightly modified from the original plan based on the discussion with the DOH, considering that the project environment has been changed from that expected at the time of project formulation. Especially the terminus of the Project was changed from Ban Lam Chi Bon in the original plan to Lup Pho near Ban Khwao. The details on this subject are discussed in Chapter VI "ROUTE SELECTION".

The Project has two major objectives. One is to facilitate the economic and human exchanges among three Changwats of Nakhon Sawan, Phetchabun and Chaiyaphum by connecting them directly. The other is to help the rural development by providing an easy access to the major markets for the inner area where some lands suitable for cultivation of crops such as

paddy, maize and cassava still remain unopened due to lack of good roads, and by providing good access between villages for the improvement of local communications. In consequence of both effects, the Project is expected to contribute greatly to the activation of the socio-economy of the whole area concerned.

In response to the request of the Royal Government of Thailand, the Japanese Government decided to conduct the feasibility study for the said project and entrusted the Japan International Cooperation Agency (hereinafter referred to as the JICA), the official agency responsible for the implementation of technical cooperation programs of the Japanese Government, with the carrying out of the study.

The JICA despatched to Thailand a fact-finding mission headed by Mr. S. Uchiyama in July 1978 for the purpose of field reconnaissance and discussion with the authorities concerned of the Royal Government of Thailand on the study. Based on the results of the said mission, the JICA organized a team of experts to carry out the feasibility study, the team headed by Mr. M. Tohi and composed of experts of Nippon Koei Co., Ltd. and Katahira & Engineers Inc., which carried out the feasibility study for the Phetchabun - Chai Badan Highway Project (Route 2269) in 1978, in the same technical cooperation program of the Japanese Government to the Royal Government of Thailand.

The study team started the work in Thailand on 10th June, 1979.

1-2 SCOPE OF STUDY

The overall objective of the study is to formulate the most economical road construction connecting three Changwats of Nakhon Sawan, Phetchabun and Chaiyaphum based on the economic and engineering analysis, and to make recommendations for the level of construction together with a course of action for its implementation.

The study is being done in three stages, namely Inception stage, Interim stage and Final stage.

The Inception stage, a half month in Japan, covered preliminary engineering and economic studies based on the available data and information collected by the fact-finding mission, including pre-study on conceivable alignments of the project road, and preparation of the Inception Report.

The Interim stage, three and a half months after the submission of the Inception Report to the DOH, covered field reconnaissance and inventory survey, economic and traffic surveys, formulation and comparison of route alternatives, projection of agricultural development, traffic forecast, preliminary design, estimation of costs and benefits, preliminary evaluation of the Project and preparation of the Interim Report. Profile and cross-section survey and laboratory tests on soil and material samples were also carried out in this stage for the refinement of engineering study in the Final stage.

The Final stage, the succeeding four and a half months in Japan, covered the refinement of traffic forecast, engineering study and project evaluation based on the comments of the DOH on the Interim Report and preparation of the Final Report.

The Final Report describes all the findings, study results and recommendations of the optimum route and the scale of the Project. The full report is presented in the following two volumes:

Volume 1 : Text
Volume 2 : Appendixes and Drawings

Volume 1 describes the procedures of the study and the results of optimum route selection and detailed study on the optimum route. Volume 2 contains technical details relating to agriculture, traffic forecast, designs, plan and profile of the optimum route, typical cross section and standard drawings of bridges and culverts.

1-3 STUDY PROCEDURE

The general work flow of the study is illustrated in figure 1-1, and described below.

Route alternatives were selected firstly on the 1/50,000 scale topographic maps and on the 1/5,000 scale maps prepared in Japan for the portions of especially difficult mountainous terrain, and were then modified based on the results of field reconnaissance, inventory survey, socio-economic and transportation economic survey, and through discussions with the DOH.

In the course of field reconnaissance, it was revealed that there would be no significant difference in traffic characteristics by route alternative, consequently in future traffic volume.

Therefore, the route comparison was made by a simplified method considering three major factors, namely, construction costs, route length and the area of potential land for agricultural development along the route.

For each route alternative, preliminary design was carried out assuming the same standard, which is soil aggregate road construction in accordance with the DOH's F5 road class, based on the 1/50,000 scale maps and information obtained through the field reconnaissance and inventory survey, and construction work quantities were calculated. By multiplying unit costs, which were derived from the analysis of the latest contracts of similar type of construction and interviews to contractors, to work quantities, construction costs were estimated for each route alternative. At the same time, the area of potential land was estimated by alternative.

Based on the comparison of the aboves, the optimum route was selected. For this selected optimum route the traffic forecast, engineering study, estimation of economic costs and benefits and economic evaluation of the Project were carried out.

Traffic surveys including traffic counts, roadside interview survey and home interview survey were carried out in the Project area and historic traffic data was collected. Agricultural, economic and demographic data were also collected from all possible sources. Based on the analysis of these data, traffic projections were made. The projected traffic volume were then used to determine the design standard.

Vehicle operating costs were derived by reviewing past studies carried out in Thailand and by updating the cost elements based on the results of interviews to manufacturers and dealers of vehicles, tyres, oils, etc.

In accordance with the design standard selected based on the result of traffic forecast and the DOH's standard, engineering studies were carried out for the optimum route in detail, and construction costs were estimated, both for financial and economic costs, together with maintenance costs.

Estimation was made for the principal benefits expected to accrue in case the Project is constructed. They are the increment of net added value of agricultural production and the savings of road users' costs of passenger and freight traffic. They were quantified in the comparison of with and without project cases.

The preliminary economic evaluation was made in comparison of costs and benefits both valued at the economic component of prices, using discount rate of 12 percent per annum. The evaluation was carried out over 20 year (1979-1998), until 15th year after the opening year persumed in 1984.

Based on the results of economic evaluation and consideration of other social and engineering aspects of the Project, the recommendations were compiled in this Report.

FIGURE 1-1 GENERAL WORK FLOW OF THE STUDY

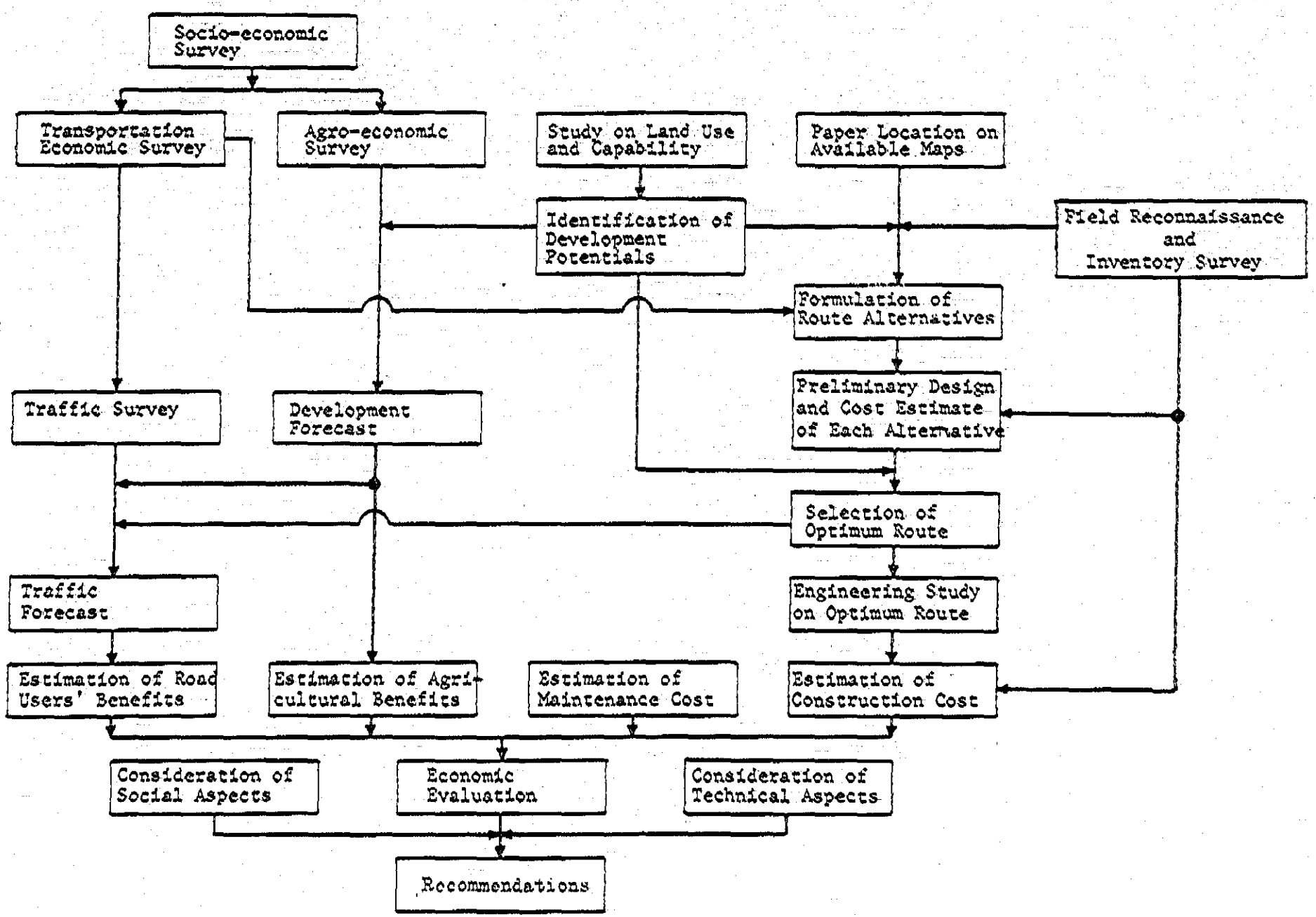
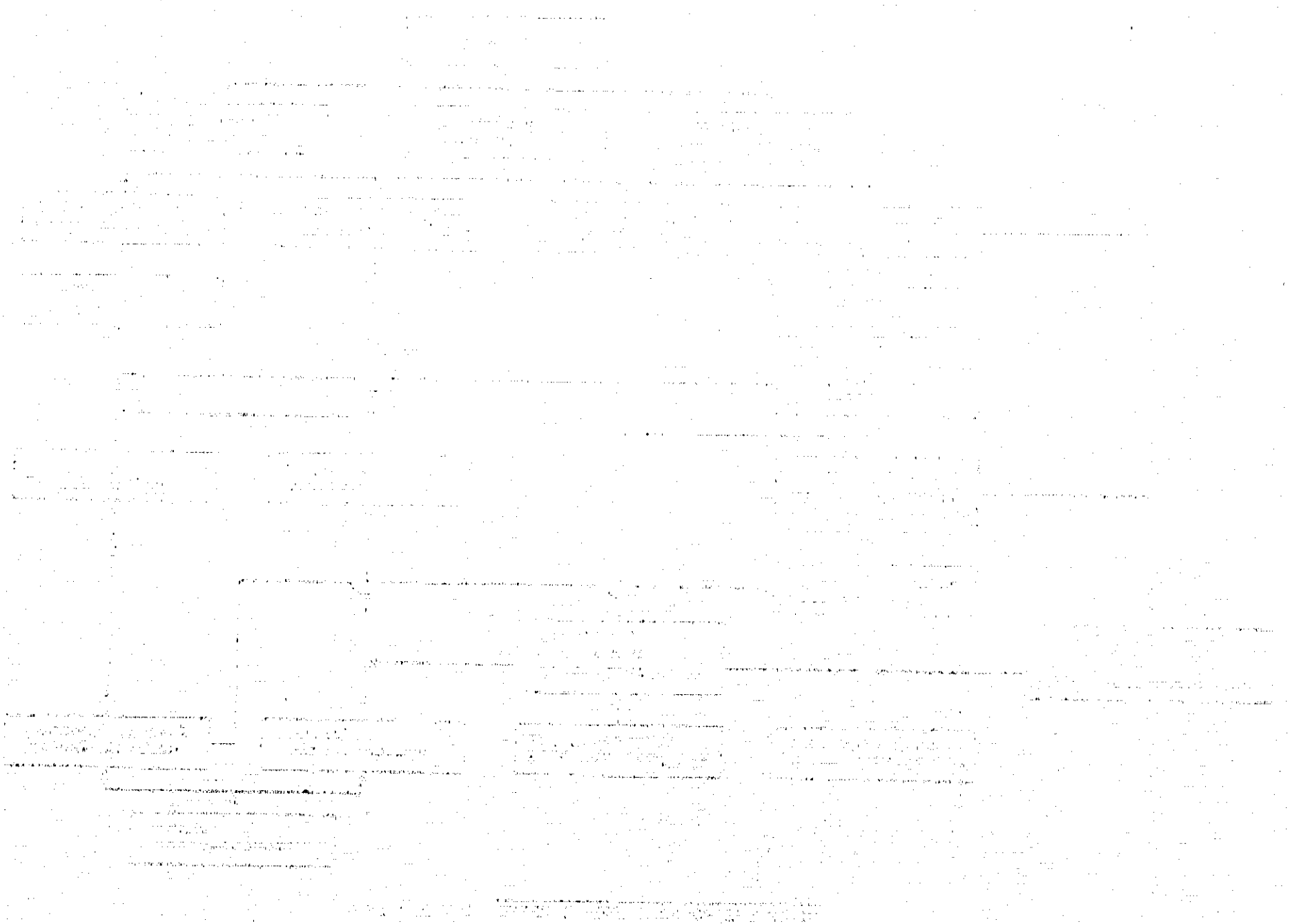


FIGURE 1-1



Chapter II

BACKGROUND OF THE PROJECT

Chapter II

BACKGROUND OF THE PROJECT

2-1 ECONOMIC BACKGROUND

Thailand has a population of about 44 million and an area of 514,000 square kilometers. Although average population density in 1978 was 80 persons per square kilometer and 85 percent of population is in the rural area, the growth of urban population, especially in Bangkok, was as high as about 5 percent while the national average was 2.7 percent.

The average rate of growth of the economy in 1970s has been decreased to 6 percent from 9 percent in 1960s. However, growth rate in 1976 showed a recovery from that in 1974 affected by oil crisis. Out of GDP in 1977, 370 billion Bahts, 20.1 percent was earned by the agricultural sector.

Agriculture is still predominant economic sector, having 63 percent of total labor force and sharing 50 to 60 percent of total value of exports. Major exported crops include rice, sugar, cassava, rubber and maize. Despite the great importance of agriculture in the national economy, recent growth of the sector has been decreased. The average growth in the Third Plan period was 3.9 percent against the planning target of 5 percent. Thus, in the future regional development program, much attention is paid to the recovery of agricultural production in order to redress the regional balance.

In the Fourth National Economic and Social Development Plan (1977-81), particular emphasis is placed on the objective of regional balance and the Plan seeks to achieve: decentralization of public investment, development of rural infrastructure, reduction of rate of population growth and dispersion of industries away from Bangkok so as to increase employment opportunities and regional incomes in rural area. From the viewpoint of the redressing of regional balance, much attention is paid to the recovery of the agricultural production together with the improvement of rural road networks.

In the Plan, which sets the target of annual growth of GDP at 7 percent, the recovery of agriculture is planned setting target rate of growth at 5 percent. To achieve the target, more attention is paid to productivity improvement than increase of planting area which is limited by the forest reservation policy. All measures to improve the rural productivity are to be taken. They include effective water control, greater application of agricultural inputs, increase of double cropping, efficient processing and handling of crops,,etc. The improvement of rural infrastructure, especially road networks, is indispensably required to ease the application of these measures for productivity improvement.

2-2 ROADS IN THAILAND

2-2-1 Road Networks

More than 10 percent of population of Thailand centers in the Bangkok Metropolitan Area. At the end of 1977, the population in Bangkok was 4,743,000, nearly fifty times of that in Nakhon Ratchasima, the second largest town. The pattern of movement for goods and passengers reflects this dominant position of Bangkok in the economy of Thailand. Primary and agricultural products are carried to Bangkok for export, processing and local consumption, while imported and locally manufactured industrial products are moved in the opposite direction. To accommodate these flows, a radial transportation system has evolved with Bangkok at the center. The road transport is a dominant mode in the system with rail and water transportations following.

The public road networks had about 12,900 kilometers of national roads and about 9,900 kilometers of provincial roads in 1977 as seen in Table 2-1. The national road system connects the main towns and regional centers throughout the country. The provincial road system links districts and other important centers or areas to provincial capitals. Since 1963 to date, the national road system has expanded from 9,100 to 12,900 kilometers, and the percentage of paved sections has increased from 46 to 94 percent. At the same time, the provincial road system has expanded from 2,200 to 9,900 kilometers, and the percentage of paved sections has increased from 9 to 49 percent. Besides the above 9,900 kilometers of provincial roads, there are 14,000 kilometers of unimproved provincial roads which receive only minimum maintenance or are under construction or improvement. As they were not constructed to a sufficient standards, many sections become impassable in rainy seasons. About 60,000 kilometers of local roads, which connect villages with national and provincial road systems, are also included in the public road networks.

The networks of national and provincial roads are illustrated in Figure 2-1.

2-2-2 Traffic

The motor vehicle fleet in whole Thailand grew at an average rate of about 10 percent per annum during 1966 - 1977 period. About 1,270,000 vehicles were registered in the country at the end of 1977 as shown in Table 2-2. Traffic distribution on the road networks reflects Bangkok's dominant situation in the economy. Traffic is highest on the approach roads to Bangkok, where it ranges from 15,000 to 30,000 in annual average daily traffic (AADT), and it decreases sharply as the distance increases from the capital. Traffic on some provincial road is over 1,000 in AADT. Traffic on local roads is generally less than 100 in AADT. Traffic growth rates on individual roads have widely varied, but have been generally higher than the increase in motor vehicle fleet.

The regulations on vehicle weights are 9.1 tons for maximum axle load, and 21 tons for gross weight of 3-axle vehicles, 37.4 tons for semi-trailer and 43.4 tons for a truck and trailer combination.

2-2-3 Administration

DOH of the Ministry of Communications is responsible for administration, planning, construction and maintenance of national and provincial roads. Provincial administrative organizations and municipal public works agencies are responsible for local roads, with assistance from the Office for Accelerated Rural Development (hereinafter referred to as ARD) and the Public and Municipal Works Department, both in the Ministry of Interior. In addition, other central government departments and agencies build and maintain roads. For example, the Royal Irrigation Department in the Ministry of Agriculture builds and maintains roads serving irrigation projects, and the Mobile Development Unit (hereinafter referred to as MDU) in the Ministry of Defence and the Army also build roads for national defence and internal security.

2-2-4 Future Road Development

The Fourth National Economic and Social Development Plan (1977-1981) includes an allocation of about 31 billion Bahts for transport sector, or about 12 percent of the total development expenditure. Road investments are about 22.3 billion Bahts, or about 73 percent of the transport allocation.

Having completed construction and improvement works on the major arterial roads, DOH is now putting emphasis on the construction of the provincial and feeder roads reaching into the remote areas. The Plans for Highway and Provincial Road Construction and Improvement (1977-1981) call for construction of 3,135.8 kilometers of national roads and 7,959.1 kilometers of provincial roads. By 1981, the length of the improved provincial road system will exceed that of national road system.

Within the context of the improvement of rural infrastructure, the Fourth National Plan is placing emphasis on the necessity of the construction of networks of rural roads, such as inter-rural roads, farm-to-market roads and roads linking rural areas with towns. Although a notable progress was achieved during the Third Plan period, the ratio of road length to acreage of cultivated land is still low comparing with international standard. In 1975, Thailand had only 145 meters of road per one square

kilometer of cultivated land while the standard recommended by IBRD was 1,500 meters. Improvement of networks of rural roads will play a crucial role in enhancing the more effective production in rural area.

The Accelerated Agricultural Roads Office, organized by DOH under coordination of other governmental agencies, is promoting the construction and improvement of rural roads to ease the delivery of farm products to market places.

Table 2-1 NATIONAL AND PROVINCIAL ROADS

(km)

Year	National roads			Provincial roads		
	Paved	Gravel	Total	Paved	Gravel	Total
1963	4,157	4,917	9,074	202	1,998	2,200
1964	4,702	4,702	9,404	257	1,957	2,214
1965	5,046	4,436	9,482	405	2,389	2,794
1966	5,008	4,490	9,498	427	2,569	2,996
1967	5,507	4,011	9,518	581	3,311	3,892
1968	6,613	3,131	9,744	1,131	4,078	5,209
1969	7,822	2,146	9,968	1,281	4,448	5,729
1970	8,620	1,781	10,401	1,479	4,413	5,892
1971	9,681	1,296	10,977	1,781	4,347	6,128
1972	10,493	1,014	11,507	2,288	3,891	6,179
1973	11,065	1,008	12,073	2,560	4,039	6,599
1974	11,750	747	12,497	3,025	3,986	7,011
1975	11,840	818	12,658	3,396	4,043	7,439
1976	11,968	752	12,720	4,276	4,601	8,877
1977	12,134	722	12,856	4,920	5,022	9,942

Source : Department of Highways

Table 2-2 MOTOR VEHICLE REGISTRATION IN THAILAND

(1,000 vehicles)

Year	Vehicle Type				
	Cars	Buses	Trucks	Motorcycles and Others	Total
1966	97.1	18.5	78.6	178.4	372.6
1970	221.8	18.7	135.7	361.4	737.6
1971	235.0	18.3	147.2	389.2	789.7
1972	240.1	20.2	159.1	413.9	833.3
1973	250.7	21.6	179.4	435.3	887.0
1974	300.9	22.7	232.4	489.9	1,045.9
1975	290.4	22.7	238.1	510.0	1,061.2
1976	298.1	20.7	275.9	554.9	1,150.4
1977/1	344.0	23.7	305.6	597.5	1,270.8

Remarks: /1 Estimated

Sources: Police Department

Figure 2-1 ROAD NETWORKS IN THAILAND

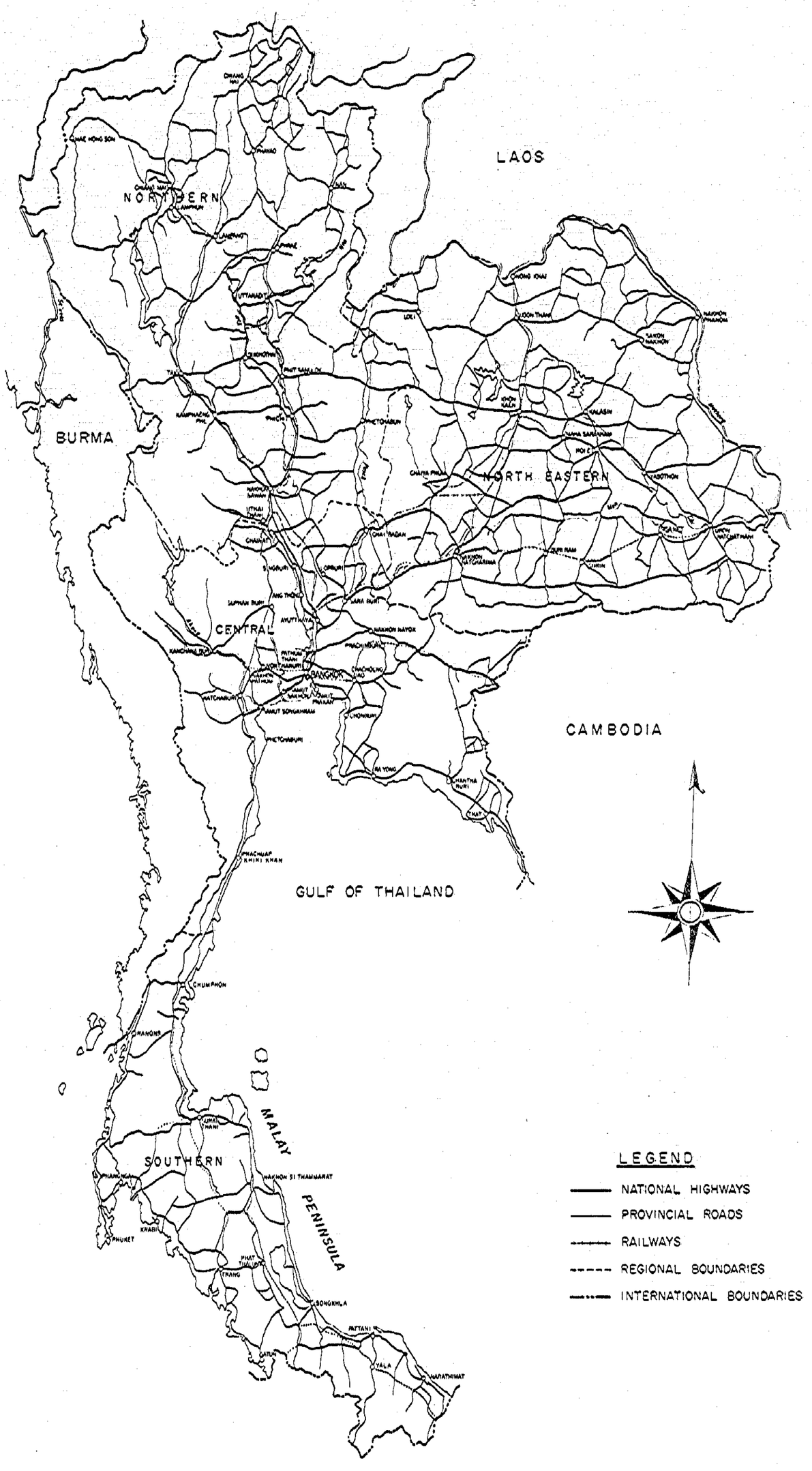


FIGURE 2-1

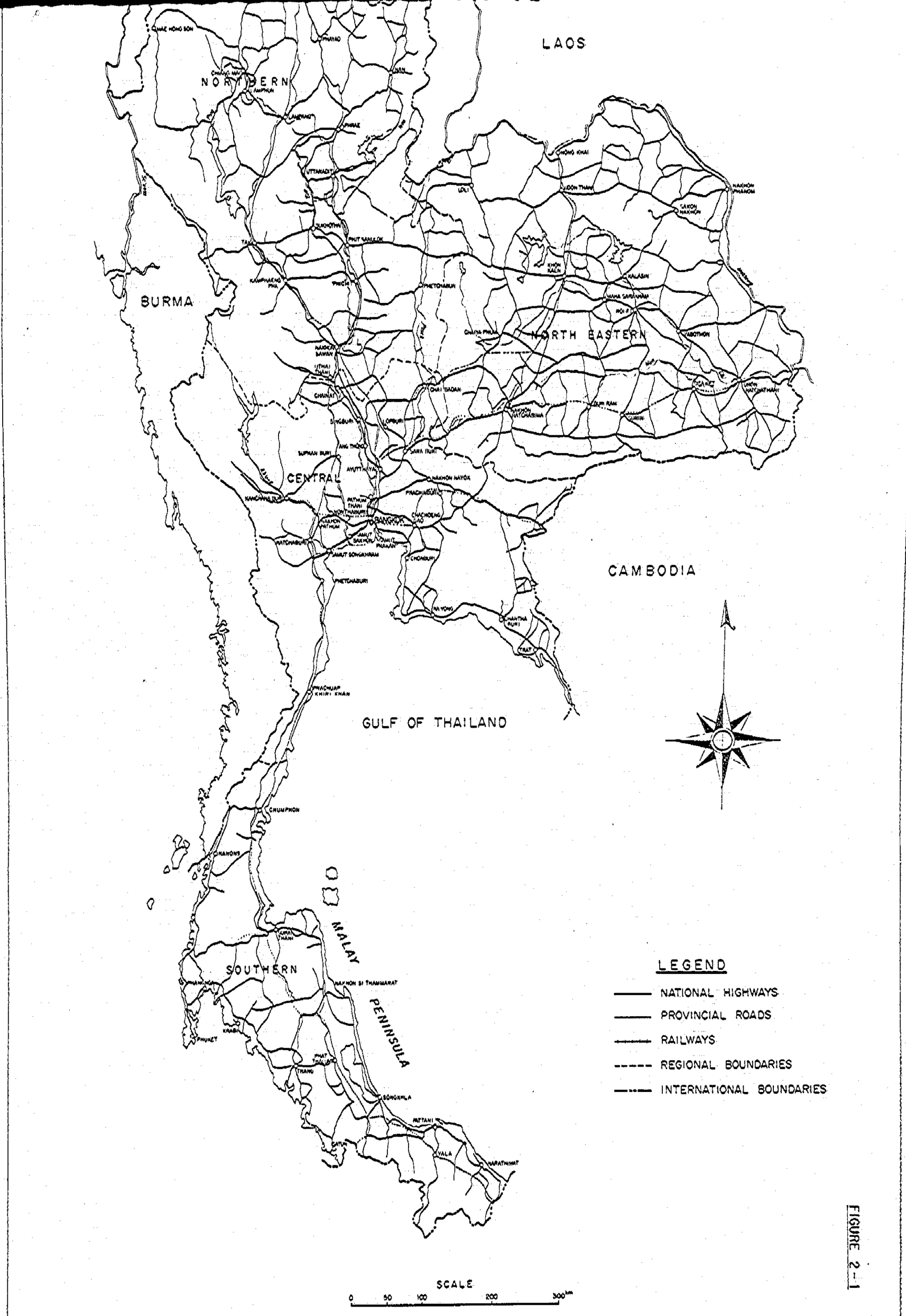

LAOS
NORTHERN
BURMA
NORTH EASTERN
CENTRAL
CAMBODIA
GULF OF THAILAND
SOUTHERN
MALAY PENINSULA
CHIANG MAI
LAMPHUN
LAMPANG
PHRAE
NAN
PHAYAO
CHIANG RAI
MAE HONG SON
UTTARADIT
SUKHOTHAI
TAK
PHITSANULOK
KAMPHAENG PHET
PHICHIT
PHETCHABUN
LOEI
UDON THANI
NONG KHAI
NAKHON PHANOM
SAKON NAKHON
KHON KAEN
KALASIN
MAHA SARAKHAM
ROI ET
CHAIYA PHUM
YASOTHON
UBON RATCHATHANI
NAKHON RATCHASIMA
BURI RAM
SURIN
NAKHON SAWAN
(THAI CHARI)
CHAINAT
SINGBURI
LOPBURI
CHAI NAT
SARA BURI
ANG THONG
SUPHAN BURI
AYUTTHAYA
NAKHON NAYOK
PRACHINBURI
KANCHANA BURI
PATHUM THANI
NONTHABURI
BANGKOK
CHACHOENG SAO
NAKHON PATHOM
RATCHABURI
SAMUT SAKHON
SAMUT PRAKAN
SAMUT SONGKHRAM
CHONBURI
PHETCHABURI
RAYONG
CHANTHA BURI
TRAT
PRACHUAP KHIRI KHAN
CHUMPHON
RANONG
SURAT THANI
NAKHON SI THAMMARAT
KRABI
PHUKET
PHATTHALUNG
TRANG
SONGKHLA
PATTANI
YALA
NARATHIWAT
SATUN
LEGEND
NATIONAL HIGHWAYS
PROVINCIAL ROADS
RAILWAYS
REGIONAL BOUNDARIES
INTERNATIONAL BOUNDARIES
SCALE
0 50 100 200 300 km

FIGURE 2-1

Chapter III

THE AREA OF INFLUENCE

Chapter III

THE AREA OF INFLUENCE

3-1 LOCATION

The area where the proposed road is located includes parts of three Changwats of Nakhon Sawan, Phetchabun and Chaiyaphum. If consideration is paid to the inter-regional through traffic to be diverted to the proposed road from the existing highways, the area of influence may extend over wider area. However, the area subject to the specific studies can be limited to the area related to the conceivable corridor which connect Nong Bua, Sap Samo Thot and Ban Khwao. This area of influence, in a narrow sense, (hereinafter referred to as the Area) deliniated by administrative boundaries includes the following Tambons shown in Figure 1A-1 of Appendix-1.

Changwat	Amphoe	Tambon
Nakhon Sawan	Nong Bua	Nong Klap, Nong Bua, Than Thahan
	Phai Sali	Wang Nam Lat
Phetchabun	Nong Phai	Ban Phat
	Bung Sam Phan	Sap Nai Daeng, Nong Chaeng, Sap Samo Thot, Kan Chu
	Wichian Buri	Khok Prong, Nam Ron, Tha Rong, Sam Yaek

Changwat	Amphoe	Tambon
Chaiyaphum	Nong Bua Daeng	Chau Thong
	Thep Sathit	Nayang Klak
	Nong Bua Rawe	Wang Takhe, Nong Bua Rawo
	Chatturat	Nong Bua Ban, Tha Kup
	Ban Khwao	Chi Bon, Talat Raeng, Ban Khwao, Lum Lam Chi

3-2 GEOGRAPHY

The geographic features of Thailand can be divided into three major provinces, the Northwest Mountain Ranges, the Korat Plateau and the Chao Phraya Plain. The Area traverses parts of the Korat Plateau and the Chao Phraya Plain. The typical geographic profile along the corridor of the proposed road is shwon in Figure 3-1, and described below:

Starting from Nong Bua, the proposed route may pass through the lowland designated as the Chao Phraya Plain, enters into the low terrace where the Rung - Sap Mai Daeng Range is located at the east end, crosses over the Pasak Valley which is a tributary of the Chao Phraya Plain, climbs up the Luak Range which separates the Chao Phraya Plain and the Korat Plateau, passes through the narrow basin along the Chao River, crosses over the escarpment of the Phang Hoei Range, runs through the undulated Korat Plateau and finally reaches Lup Pho near Amphoe Ban Khwao about 19.5 km west of Chaiyaphum.

The lowland involved in the Chao Phraya Plain ends just over the east side of Nong Bua. The elevation of this lowland is about 40 m above sea level. The low terrace adjoining to this lowland is sloping gently up eastwards with the elevation from 50 to 150m above sea level and approaching the Reng - Sap Mai Daeng Range. In the terrace, there are some isolated hills and numbers of rivers.

The Rung - Sap Mai Daneg Range runs from north to south along the east margin of the above-mentioned terrace. The average altitude of this mountain range is about 400 m. The difference in altitude between the

terrace and the mountain range is about 250 m. Many cols of low elevation exist along the mountain range and this makes routing works easy.

The Pasak Valley is the lowland formed by the flood deposits of the Pasak River and its tributaries. This lowland, about 60 m above sea level in the average elevation, is classified as a part of the Chao Phraya Plain. The annual floods in this lowland require high embankment and numbers of long bridges for relief open when the road is designated to pass this area.

The Luak Range which has the wide piedmont running in a north-south direction is steep and severely undulated. It rises high abruptly from the lowland of the Pasak Valley and forms the border line between the Chao Phraya Plain and the Korat Plateau. The average elevation of the range is about 500 m, but the lowest portion is about 350 m above sea level. The route should be selected to cross over the range at this lowest portion.

Passed through the Luak Range, the narrow basin which is sandwiched by two mountain ranges, the Luak and the Phang Hoei, is found. The altitude of this basin is rather high as about 300 m. In this basin the Chao River which is one of the tributaries of the Chi River flows north.

The Phang Hoei Range rises up high on the east of the basin. This mountain range is steep itself and has the continuous precipice of sandstone outcrop on the summit. Therefore, the large quantities of hard rock excavation is required in this section. The average elevation of this mountain range is high as about 700 m above sea level. However, the lowest point of 500 m was found in the pre-study. The route is to be planned to cross over at this point.

On the east of the Phang Hoei Range, the Korat Plateau extends with small undulations. There are a lot of isolated hills and rivers, the Chi River and its tributaries, in this plateau. The elevation of this area is about 200 m above sea level.

3-3 GEOLOGY

Geology of Thailand consists of diversified formations of sedimentary and metamorphic and igneous rocks ranging from the Canbrian age to the Recent age.

The geological map of the Area is shown in Figure 1A-2 of Appendix-1. As shown in this figure, the following formations are found in the Area, ranging from the Carboniferous and Permian age to the Recent age.

- Ratburi formation of the Carboniferous and Permian age
- Phu Kradung formation of the Jurassic and Triassic age
- Phu Phan and Phra Wihan formation of the Jurassic age
- Salt and Khok Kruat formation of the Cretaceous age
- Igneous rocks of the Tertiary age
- Alluvium and Eluvium deposits of the Quarternary and Recent age

The Chao Phraya Plain around Nong Bua is covered with clay, sand, silt and gravel of mainly alluvium and eluvium deposits, with some in-site deposits which are products of leaching or weathering.

The low terrace bordered on the Chao Phraya Plain can be divided into two geological formations. The western part of this terrace consists of igneous rocks of the Tertiary age, granite, diorite and rhyorite, covered with thin top soils. On the other hand, the eastern part of this terrace is classified as the Phu Kradung formation whose bed rocks are sedimentary and metamorphic rocks, dark brown micaceous shale with some siltstone and sandstone. The top soils are mainly thin in-site deposits.

The Rung - Sap Mai Daeng Range located along the east margin of this terrace is identified as the Ratburi formation made up of mainly sedimentary and metamorphic rocks, massive light gray limestone interbeded with shale, sandstone, mudstone and some volcanic tuff. The resistant limestone outcrops are found here and there in this mountain range.

The Pasak Valley is covered with the thick deposits of the Recent age composed of yellowish and grayish silty clay with some fine sand underlain by eroded sandstone, limestone and others.

The Luak Range and its piedmont are included in Ratburi formation consisted of such rocks, as massive light gray limestone, sandstone and shale. The outcrops of these rocks exist in many places. The top soils are thin and of almost in-site deposits.

The narrow basin between two mountain ranges, the Luak and the Phang Hoei is included in the Phu Kradung formation. This formation is composed of dark, brown micaceous shale with some siltstone and sandstone. The top soils are of mainly in-site deposits produced by leaching or wheathering.

The Phang Hoei Range consists of the Phu Phan and Phra Wihan formation whose bed rocks are sedimentary and metamorphic rocks as gray or white colored massive sandstone, micaceous shale and siltstone. The continuous precipice of sandstone outcrops can be seen on the summit of this mountain range. The top soils are made up of the deposits produced by leaching and weathering.

The Korat Plateau in the Area is classified as the Salt and Khok Kruat formation whose bed rocks are such sedimentary and metamorphic rocks as gray, red, or white sandstone, shale and siltstone with rock salt. The top soils are mainly in-site deposits and very thin in the western part of the Area. The lowland along the rivers are covered with thin deposits produced by the floods of rivers.

3-4 CLIMATE

The climate of Thailand is tropical and monsoonal, since Thailand is located close to the equator and its altitude is mostly quite low. It is characterized by distinct two seasons, rainy season from May to October and dry season from November to April.

The Area is situated in the central part of Thailand and is subject to the typical climate of Thailand. The temperature in the Area is warm and hot throughout the year and is suitable for growing crops. The temperature is 28°C in annual average, ranging between 27°C and 37°C in rainy season, and between 21°C and 32°C in dry season.

In the Area, about 120 rainy days bring the rainfall of approximately 1250 mm per year. Almost 90 percent of annual rainfall, about 1,100 mm in average, concentrates in the rainy season. At Nakhon Sawan rainfall gauging station, for example, the mean monthly rainfall varies from 5 mm in December to 280 mm in September. The rainfall in rainy season offers enough water for growing paddy but at the same time causes often floods. While, in dry season, only few crops can be grown without irrigation systems.

3-5 LAND USE AND LAND CAPABILITY

3-5-1 Land Use

The map of the present land use in the Area is shown in Figure 2A-1 of Appendix-2. The land use map of 1/100,000 scale, which was prepared by the Department of Land Development based on the aerial photos shot in 1969-1971, was availed as the base map of the study. This map revised by our field survey as well as aerial photos taken in 1974-1976.

Based on the revised land use map, the present land use in the Area was estimated by crop, as shown below:

Land Use in the Area of Influence in 1979

(rai)

	Changwat			Total
	Nakhon Sawan	Phetchabun	Chaiyaphum	
Cultivated lands	237,590(100%)	433,660(100%)	171,550(100%)	842,800(100%)
Paddy	124,400(52%)	71,810(17%)	56,640(33%)	252,850(30%)
Upland crops				
Maize	87,100(37%)	275,550(63%)	33,260(20%)	395,910(47%)
Cassava	-	-	39,620(23%)	39,620(5%)
Kenaf	-	2,240(1%)	38,560(22%)	40,800(5%)
Mung beans	18,210(8%)	51,750(12%)	350(-)	70,310(8%)
Others[1/]	7,880(3%)	32,310(7%)	3,120(2%)	43,310(5%)
Uncultivated lands	111,450	247,100	798,600	1,157,150
Total	349,040	680,760	970,150	1,999,950

Note: 1/ Others include cotton, groundnuts, soy beans, sorghum, sesame and vegetables.

Major characteristics of the land use in the Area are briefly mentioned below:

- Paddy field occupies the alluvial plains of the Sat River in Nakhon Sawan, that of the Pasak River in Phetchabun and that of the Chi River in Chaiyaphum.
- In the upland crop lands, maize is a dominant crop in Nakhon Sawan and Phetchabun, while kenaf, cassava and maize are mixed in Chaiyaphum.
- Mung beans, soy beans, sorghum, sesame and groundnuts are mainly planted as the second or inter crops of the above main crops.
- Vegetables are planted in a small scale for farmers' own consumption or to the limited local markets.

- The most of lands suitable for paddy cultivation is already opened, and only scattered small area remain unopened due mainly to the poor access to such areas.
- Although some areas are designated as forest reserves, it has been practiced to allow the cultivation in the forest reserves if the areas are agriculturally productive. Actually, the cultivation is made in the forest reserves except mountainous areas.
- The forest lands on rolling topography in the central part or the Area in the foot of the Luak Range and the Phang Hoei Range are not fully opened and have potential for further expansion of cultivation, especially of maize.
- The forest lands in the sourthern part of high terraces, in the east of the Phang Hoei Range are not yet used for agricultural crops, but have high potentials for new cultivation of upland crops.
- The forest lands in mountainous area and on isolated hill are not used for agricultural crops due to steep slope and shallow thickness of soils.

3-5-2 Land Capability

The maps of land capability of the uncultivated land were prepared, separately for paddy and for upland crops as shown in Figure 2A-2 and 2A-3 of Appendix-2. In preparing them, the following factors were taken into consideration:

- Topography
- Physical and chemical characteristics of soils
- Possibility and degree of flood
- Possibility of erosion
- Availability of irrigation water supply
- Forest to be reserved

Among them, the physical and chemical characteristics of soils are the most important factor. The soils in the Area consist of eleven classifications

in agricultural sense as shown in Table 2A-1 of Appendix-2.

Degree of land capability was classified into five categories in accordance with the classification of the Department of Land Development, namely, Class I (most suited, but does not appear in the Area), Class II (well suited), Class III (moderately suited), Class IV (poorly suited) and Class V (unsuited). The land capability of the uncultivated lands in the Area is briefly described below:

1) For Paddy

- Well suited lands (Class II) occupy semi-recent terraces in the western part of the Area, flood plains along the Pasak River and semi-recent terraces in the central part and flood plains along the Chi River in the eastern part. Soils are Hydromorphic Alluvial Soils, Hydromorphic Non Calcic Brown Soils and Grumsols. However, the area of this class is very small.
- Moderately suited lands (Class III) occupy low terraces in the western and the central parts of the Area. Soils are Low Humic Gley Soils.
- Poorly suited lands (Class IV) occupy mainly high terraces in the western part and low terraces in the central part of the Area. Soils are Red Yellow Podzolic Soils and Hydromorphic Non Calcic Brown Soils.
- Unsuited lands (Class V) occupy middle and high terraces, hills and dissected erosion surface. Soils are Reddisi Brown Lateritic Soils, Gray Podzolic Soils, Red Yellow Latsols, Regosolic Soils and Brown Forest Soils. Slop complex areas in the mountains also fall into this category because of their erosive characteristics and shallow thickness of soils.

2) For Upland Crops

- Well suited lands (Class II) cover hills and dissected erosion surface in the area along the skirt of mountains, mainly in the central part of the Area. Soils are Red Yellow Podzolic Soils and Brown Lateritic Soils.

- Moderately suited lands (class III) mainly occupy hills and dissected erosion surface in the central part and middle and high terraces and hills and dissected erosion surface in the eastern part. Especially, the forest lands on rolling topography in the eastern part of the Area have vast potentials for new cultivation. Soils are Red Yellow Podzolic Soils, Gray Podzolic Soils, Red Yellow Latosols and Brown Forest Soils.
- Poorly suited lands (Class IV) occupy hills and dissected surface in the western part, and flood plains along the Pasak River and low and semi-recent terraces in the central part of the Area. Soils are Hydromorphic Alluvial Soils, Hydromorphic Non Calcic Brown Soils and Grumsols.
- Unsuited lands (Class V) are located in steep mountain areas, especially in the central and the eastern parts of the Areas, due to steep erosive slope and shallow thickness of soils. They should be maintained unopened to protect from severe erosion and ecological distortion.

Based on the land capability maps, the uncultivated lands in the Area were classified into i) Suited for paddy, ii) Suited for upland crops and iii) Unsuited for cultivation, as shown below:

Suitability of Uncultivated Land in the Area in 1979

(rai)

	Changwat			Total
	Nakhon Sawan	Phetchabun	Chaiyaphum	
Suited for paddy	8,950	4,890	10,950	24,790
Suited for upland crops	95,470	80,350	287,470	463,290
Unsuited	7,030	161,860	500,180	669,070
Total	111,450	247,100	798,600	1,157,150

3-6 POPULATION

The compiled records of population were available at Amphoe level. Population of each related Amphoe in the Area in the past three years is as follows:

Population of the Related Amphoes

Changwat	Amphoe	1976	1977	1978
Nakhon Sawan	Nong Bua	56,179	57,423	58,893
	Phai Sali	59,290	60,398	61,235
Phetchabun	Nong Phai	91,682	94,188	103,943
	Bung Sam Phan	58,517	58,091	59,359
	Wichian Buri	80,701	82,877	86,350
Chaiyaphum	Nong Bua Daeng	63,683	66,581	69,376
	Thep Sathit	19,677	20,818	28,191
	Chatturat 1/	106,765	107,876	109,450
	Ban Khwao	41,893	42,635	45,443
Total		578,387	590,887	622,240

Note: 1/ including King Amphoe Nong Bua Rawe.

The population density in the related Amphoes was, in average, 66 persons per km^2 in 1978. The densities of mountainous areas, such as Amphoe Nong Bua Daeng and King Amphoe Nong Bua Rawe are lower than those in other areas because of the delay of the development. The average population growth of the related Amphoes was 3.7 percent per annum in 1976-1978 period.

In order to find the population of the Area, further divided population data at Tambon level was collected from Amphoe offices. This data has some discrepancies due to the recent re-organization of Tambons. The population of the Area was estimated, therefore, based on the collected population data at Tambon level adjusting with the population of Amphoes as control total. The population of the Area is estimated at 276,876 in

1979 and details are shown in Table 1A-1 of Appendix-1.

3-7 ECONOMIC ACTIVITIES

Estimated Gross Provincial Products (GPP) in 1977 were 4,842.8 million Baht in Changwat Nakhon Sawan, 4,019.6 million Baht in Phetchabun and 2,730.9 million Baht in Chaiyaphum. Agriculture is the most dominant sector in the economy of the Area. Although the share of earnings from agricultural sector in GPP ranges 43 to 62 percent differing by Changwat, the Area itself is entirely sustained by agricultural economy. The share of manufacturing sector is only around 10 percent in each Changwat. Towns adjacent to the Area have several kinds of agro-based industries such as cassava pelleting factories, peanut cracking factories, especially in Chaiyaphum side. Effects of the project to the industrial sector would be negligible small.

Existing economic movements depend fully on the condition of road transportation. Economies of the rural areas are exclusively connected with those of the accessible towns along national highways. For example, on the Phetchabun side, villages tend to have economic connections with Sap Samo Thot or Wichian Buri. Villages on the Chaiyaphum side have been used to be connected economically with Chaiyaphum city for left bank of the Chi River and with Chatturat or Bamnet Narong for the other side of the river. These conventional relationships depend on the road transport condition and consequently be changed when improvement of road network be realized.

Economic exchanges on an inter-Changwat basis also depend on te availability of the road transportation. At present, there exist some exchanges between the Nakhon Sawan and the Phetchabun sides, but no direct exchange exists between the Phetchabun and the Chaiyaphum sides due to the lack of road crossing over the mountain ranges between both sides. In case the Project road be completed, the economic exchanges between Changwats will be activated greatly.

3-8 AGRICULTURE

3-8-1 Production, Consumption and Surplus

1) Cropping Pattern and Production

Cropping pattern in the Area differs by region. However, as the patterns are similar in the area belong to Changwat Nakhon Sawan and the area in the Phetchabun side, these two areas are grouped into one zone in an agricultural sense. Major crops, which cover more than 95 percent of the planted area, include paddy, maize and mung beans in Nakhon Sawan/Phetchabun side, while those are paddy, cassava and kenaf in Chaiyaphum side. Other crops are minor in the Area. Typical cropping calendars of each Changwat are shown in Figure 3A-1 of Appendix-3. Planted area and production in the Area in 1978/1979 were estimated based on the field survey information as follows:

Planted Area and Production in the Area of Influence in 1978/79

(Unit: 1,000 rai and 1,000 ton)

	Nakhon Sawan/ Phetchabun Side		Chaiyaphum Side	
	Area	Prod'n	Area	Prod'n
Paddy	196.2	62.8	56.6	15.8
Maize	362.7	119.8	33.3	9.9
Cassava	-	-	39.6	82.8
Kenaf	2.2	0.4	38.6	9.7
Mung Beans	70.0	9.1	0.4	0.1
Others	7.9		3.1	

Maize production is the biggest among the crop production in the Area, especially in Nakhon Sawan/Phetchabun side. Amount of maize production in the Area in 1978 was estimated at 130,000 tons from 396,000 rai of planted area. As harvesting time of maize is in rainy season, road

condition is the most crucial factor for marketing of maize.

Paddy is also an important crop in the Area. It is planted in July, trans-planted in August to September and harvested in November to December. In 1978, 79,000 tons of paddy was produced from 253,000 rai of planted area.

Mung beans is one of the major second crops in maize and paddy fields. Its planted area in 1978 in the Area was about 70,000 rai and 9,000 tons of production was attained. Mung beans is mainly planted as either intercrops or second crops of paddy or upland crops, especially maize.

Cassava and kenaf are the major crops sharing 20 to 30 percent of planted area in Chaiyaphum side, 40,000 rai for cassava and 41,000 rai for kenaf. Production in the Area in 1978 was estimated at 83,000 tons for cassava and 10,000 tons for kenaf. Due to the remarkable increase of export demand, the planted area of cassava has been expanded rapidly in these five years. Critical problems for cassava cultivation are longer growing period of 12 to 13 months and degrading of soil fertility by continuous cultivation. In order to avoid the latter problem, it is recommended to use chemical fertilizer. Kenaf is used for the material of gunny bag and industrial yarn. Its growing period is around 6 months from May to December. Due to the decrease of local demand for gunny bag, the planted area of kenaf is gradually decreasing or being converted to other variety of jute suitable for exportable fiber.

Other minor crops are cultivated in both low land and upland fields as inter or second crops of the above-mentioned major crops. They include soy beans, groundnuts, sorghum, sesame, cotton and vegetables.

2) Average Yield

Although the trends of crop production during the period of 1971 to 1978 in the related Changwats have been fluctuated according to the acreage of planting and the local weather conditions in each year,

those of major upland crops such as maize, cassava and kenaf in the Study Area have been increased year by year owing to the expansion of new cultivated land. On the other hand, the trends of average yield per acreage were almost same or decreased due to the degraded soil condition of old cultivated land or damages of insects and pests. This tendency may be improved by application of fertilizer and agro-chemicals or improvement of farm management in the future.

The past trends of production amount and average yield are shown in Tables of Appendix-3. Judging from these trends and field survey information, the average crop yield per rai in the Area were presumed as follows:

Average Crop Yield

(kg/rai)

Crops	Nakon Sawan/ Phetchabun	Chaiyahum
Major Crops		
Paddy	320	280
Maize	330	295
Mung beans	130	130
Cassava	-	2,090
Kenaf	160	250
Minor Crops		
Soy beans	180	175
Ground nuts	185	190
Sorghum	230	200
Cotton	225	220

3) Consumption and Surplus

Out of total production of paddy in the Area, about 75 percent is consumed within the Area. Residual 25 percent, about 20,000 tons of paddy or 13,000 tons of rice, is sent to towns nearby or cities in

the Central Region.

Maize is produced mainly for export. Local consumption is very few. Almost 100 percent is sent out of the Area to Tha Rua or Bangkok.

Cassava is also produced for exportable products. It is seldom consured locally and send to the factories outside the Area. Kenaf is produced for materials of gunny bag and industrial yarn which are manufactured in the factories in Korat area.

Other upland crops are mostly sent to wholesale markets outside of the Area. Some amount, about 5 percent, of soy beans and groundnuts was estimated to be consumed on farms or within villages. Vegetables and fruits are mainly for self-consumption of farmers households but about 50 percent may be sold in the neighbouring towns.

3-8-2 Farm Economy

1) Production Costs

Based on the data compiled by the Ministry of Agriculture and referring to the field survey information, the crop production costs in the Area were estimated as follows:

Crop Production Costs in 1978/1979

(Baht/rai)

	Nakhon Sawan/ Phetchabun Side		Chaiyaphum Side	
	Variable Cost	Fixed Cost	Variable Cost	Fixed Cost
Paddy	440	50	410	50
Maize	370	40	308	30
Mung Beans	405	40	430	30
Cassava	-	-	475	80
Kenaf	505	40	505	30
Soy Beans	380	40	410	30
Groundnuts	755	40	785	30

Sorghum	175	40	190	30
Cotton	940	40	970	30

Details are shown in Table 3A-3 of Appendix 3.

2) Crop Income

Average holdings of cultivated land in the Area are 25 rai on Nakhon Sawan/Phetchabun side and 20 rai on Chaiyaphum side. Net crop incomes, deducting production costs from gross production value, of typical farms were estimated in 1978 price as follows:

Net Crop Income of Typical Farm in 1978/79

(Baht/household/year)

	Nakhon Sawan/ Phetchabun Side	Chaiyaphum Side
Rice Farm	7,217	4,367
Maize Farm	3,442	2,728
Cassava/Kenaf Farm	-	7,210

Details are shown in Table 3A-4 of Appendix 3.

Farm income of rice farm is much better than maize farm in Nakhon Sawan/Phetchabun, and in Chaiyaphum cassava/kenaf farm earns higher net income than rice farm owing to the rapid increase of price of cassava products. Beside crop incomes, rice farm and maize farm usually have extra earnings such as labor wages from other farms or non-agricultural incomes, while it is difficult for cassava farm to obtain extra earnings due to the all year round cultivation required for cassava.

3-8-3 Processing and Marketing

1) Marketing of Maize

a) Local Markets

Usually farmers bring their products to local assembling spots in the centers of villages to sell them to middlemen. Sometimes middlemen go to farm to buy crops at the farm site. Shelling and sacking are made at the trading spots, usually by tractors with shelling machine brought by middlemen.

Prices at local markets are lower than those at assembly markets on the trunk roads. Transportation cost to be included in the prices varies depending on road conditions between farms to markets. Improvement of road network will shorten the economic distance between farms and markets and consequently bring about savings of transporation cost.

b) Assembly Markets

Assembly markets in the Area are established in Nakhon Sawan/ Phetchabun side but market special for maize is not yet established in Chaiyaphum side. Most of middlemen in the assembly markets collect products from farmers or collecting agents and send them to Tha Rua or Bangkok after grading and re-sacking.

Price difference between the assembly markets and production spots varies depending on road conditions. The field survey found that there is more than ten Bahts of difference per bag (100 kg) between selling prices of farmers near to the markets and those of farmers in remote places, over 10 km away from the markets on an average.

c) Terminal Markets

Terminal markets are in Tha Rua, about 20 km west of Sara Buri, and in Bangkok. As merchants in terminal markets have big silos and stores, they are able to control by themselves the timing of shipment according to the export market situation.