

JAPAN INTERNATIONAL COOPERATION AGENCY

DEPARTMENT OF HIGHWAYS  
MINISTRY OF TRANSPORT AND COMMUNICATIONS  
KINGDOM OF THAILAND

FEASIBILITY STUDY  
ON  
THE INTER-CITY TOLL MOTORWAY PROJECTS  
IN  
THE KINGDOM OF THAILAND

FINAL REPORT

VOLUME II  
MAIN TEXT

MARCH 1995

KATAHIRA & ENGINEERS INTERNATIONAL  
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## PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Government of Japan decided to conduct the Feasibility Study on the Inter-city Toll Motorway Projects and entrusted the study to the Japan International Cooperation Agency (JICA).

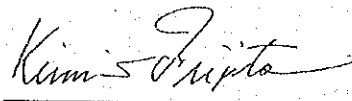
JICA sent to the Thailand a study team headed by Mr. Masahiko Tohi and Mr. Kunihiko Sawano of Katahira & Engineers International, and composed of members from Katahira & Engineers International, Nippon Koei Co., Ltd. and Kokusai Kogyo Co., Ltd. twice between August 1993 and March 1995.

The team held discussions with the officials concerned of the Government of the Kingdom of Thailand, and conducted field surveys at the study areas. After the Team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the projects and to the enhancement of friendly relations between the two countries.

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

March, 1995



Kimio Fujita  
President  
Japan International Cooperation Agency

March 7, 1995

Mr. Kimio Fujita  
President,  
Japan International Cooperation Agency  
Tokyo, Japan

Dear Mr. Fujita,

Letter of Transmittal

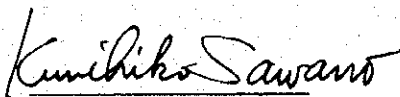
We are pleased to submit to you the Final Report of the Feasibility Study on the Inter-city Toll Motorway Projects in the Kingdom of Thailand. The report contains the advice and suggestions of the authorities concerned of the Government of Japan and your Agency as well as the formulation of the above mentioned feasibility study.

This report presents the results of feasibility study on two inter-city toll motorways, Lampang - Doi Saket Route and Ban Pong - Cha Am Route, among 4,300 km nationwide inter-city motorway network proposed by the master plan study in 1991. Taking into the priority of the projects and the possible investment amount, the implementation schedule is developed and recommendations to facilitate the implementation are made.

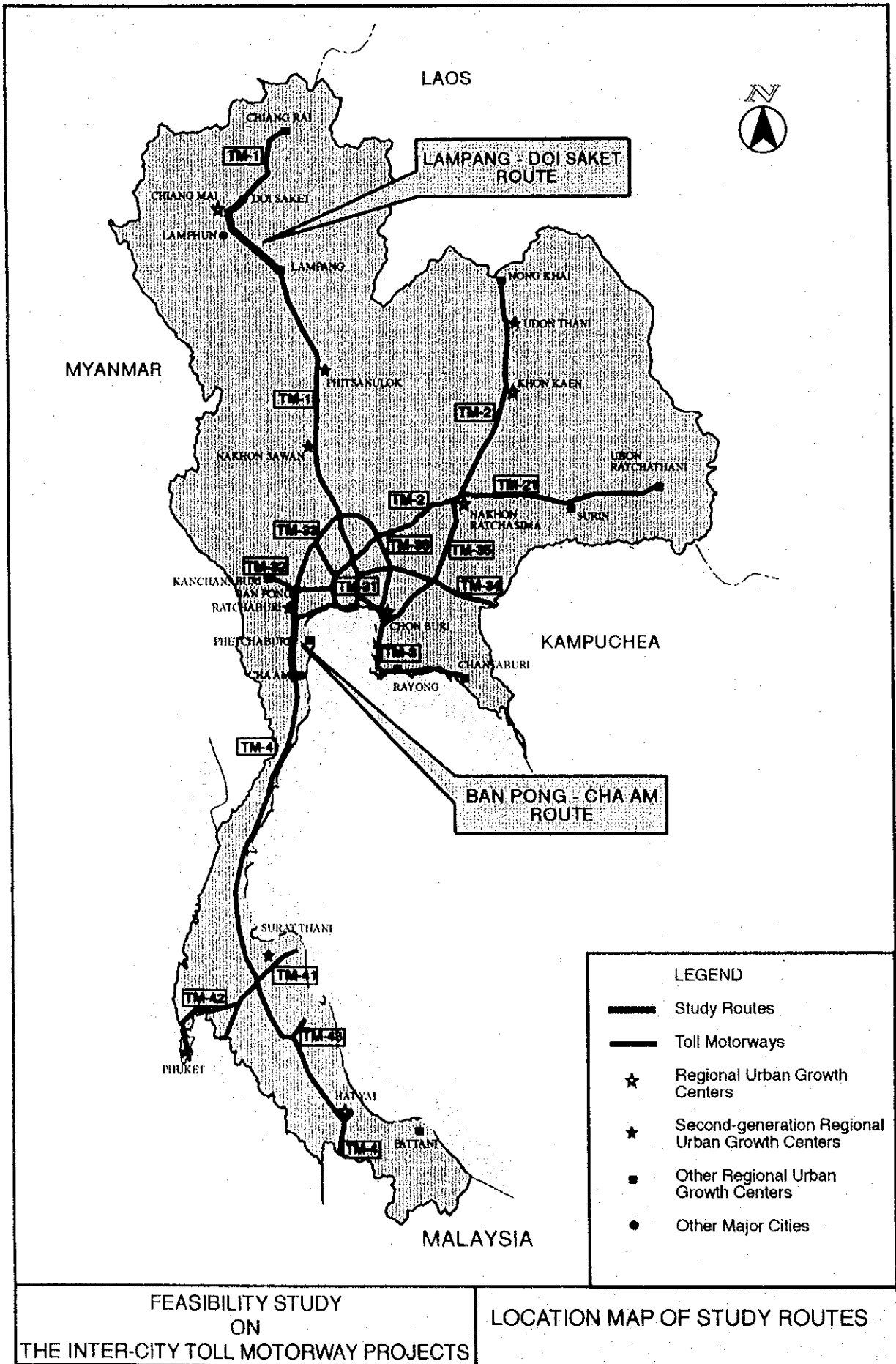
In view of the urgency in well-balanced development of the whole nation by decentralizing socio-economic activities from Bangkok metropolitan area, and the continuation of stable economic growth in the whole country, we recommended that the Government of the Kingdom of Thailand materializes this results as a top priority.

We wish to take this opportunity to express our sincere gratitude to your Agency, Ministry of Foreign Affairs and Ministry of Construction. We also wish to express our deep gratitude to the Department of Highways and other authorities concerned of the Government of the Kingdom of Thailand for the close cooperation and assistance extended to us during the course of the Study.

Very truly yours,



Kunihiko Sawano  
Team Leader,  
Feasibility Study  
on the Inter-city Toll Motorway Projects  
in the Kingdom of Thailand





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## ABBREVIATIONS

AADT	: Annual Average Daily Traffic
AASHTO	: American Association State Highway and Transportation Officials
AC	: Asphalt Concrete
ADB	: Asian Development Bank
ADT	: Average Daily Traffic
Alignment	: Alignment
AR	: Alternative Route
ASB	: Amber Security Beacon
AVC	: Automatic Vehicle Classification Unit
B-C	: Ban Pong-Cha Am, B/C
BMR	: Bangkok Metropolitan
BOD	: Biochemical Oxygen Demand
BOT	: Built-Operate-and-Transfer
B/S	: Bus Stop
BT	: Build-and-Transfer
CBR	: California Bearing Ratio
CCTV	: Closed-circuit Television
cd/m <sup>2</sup>	: Candle per Square Meter
CL	: Climbing Lane
CL	: Silty Clay
CO	: Carbon Monoxide
CRF	: Conversion Ratio of Fare Burden
C/V	: Capacity/Design Traffic Volume
DAC	: Development Assistance Committee
dba	: Decibel
DDG	: Deputy Director General
DDHV	: Directional Design Hour Volume
DG	: Director General
DHV	: Directional Hour Volume
DO	: Dissolved Oxygen
DOH	: Department of Highways
DTV	: Daily Traffic Volume
EB	: Passenger Car Equivalent for Buses
EE	: Environmental Examination
EIA	: Environmental Impact Assessment
EIRR	: Economic Internal Rate of Return
ET	: Passenger Car Equivalent for Trucks
ETA	: Expressway and Rapid Transit Authority of Thailand
FHWA	: Federal Highway Administration (USA)
FIO	: Forest Industry Organization
FIRR	: Financial Internal Rate of Return
GDP	: Gross Domestic Product
GOT	: Government of Thailand
GPP	: Gross Provincial Product
GRP	: Gross Regional Product
HB	: Heavy Bus

HCM	: Highway Capacity Manual
HT	: Heavy Truck
I/C	: Interchange
ICMA	: Inter-City Motorway Authority
IEE	: Initial Environmental Examination
IFC	: International Finance Corporation
IHV	: Interchange Hour Volume
ILI	: International Financial Institution
IRR	: Internal Rate of Return
J/C	: Junction
JHPC	: Japan Highway Public Corporation
JICA	: Japan International Cooperation Agency
k.p.h	: Kilometer per Hour, Kmph
LB	: Light Bus
LCB	: Lane Closure Barrier
LCL	: Lane Controller
L-D	: Lampang-Doi Saket, L/D
Ldn	: Day-Night Sound Level
Leq	: Equivalent Sound Level
Leq <sub>(24)</sub>	: 24-Hour Equivalent Sound Level
Leq <sub>(h)</sub>	: 1-Hour Equivalent Sound Level
LOS	: Level of Service
LT	: Light Truck
LTD	: Land Transport Department
LTL	: Lane Traffic Light
MB	: Medium Truck
MC	: Motorcycle
mg/m <sup>3</sup>	: Milligram per Cubic Meter
MH	: Silt
MOAC	: Ministry of Agriculture and Cooperatives
MOC	: Ministry of Construction in Japan
MOSTE	: Ministry of Science, Technology and Environment
MOTC	: Ministry of Transport and Communications
MPa	: 1 MPa = 9.8 kgf/cm <sup>2</sup>
m.p.h	: Mile per Hour
MSF	: Maximum Service Flow Rate
MT	: Medium Truck
NATM	: New Austrian Tunneling Method
NEB	: National Environment Board
NESDB	: National Economic and Social Development Board
NO <sub>2</sub>	: Nitrogen Dioxide
NOx	: Oxides of Nitrogen
NPV	: Net Present Value
OBRM	: Outer Bangkok Ring Motorway
OBRR	: Outer Bangkok Ring Road
OD	: Origin-Destination
ODA	: Official Development Assistance
OECF	: Overseas Economic Cooperation Fund of Japan
OEPP	: Office of Environmental Policy and Planning, MOSTE (Thailand)



OTL	: Overhead Traffic Light
O&M	: Operation and Maintenance
Pb	: Lead
PC	: Passenger Car
PCC	: Portland Cement Concrete
pcphpl	: Passenger Car per Hour per Lane
PCU	: Passenger Car Unit
PH	: Planed Hight
PIARC	: Permanent International Association of Road Congresses
PP	: Pick-up (passenger)
PU	: Pick-up
R/A	: Rest Area
R&D	: Research and Development
ROW	: Right of Ways
RPR	: Receipt Printer
Rt.	: Route number of National Highway
S/A	: Service Area
SC	: Clayey Sand
SFL	: Service Flow Rate per Lane
SL	: Spring Line
SM	: Silty Sand
SO <sub>2</sub>	: Sulfur Dioxide
SPC	: Station Processor
SRT	: State Railway of Thailand
SS	: Suspended Solid
STA	: Station
TC	: Tricycle (with engine)
TCT	: Toll Collector Terminal
TEV	: Time Evaluation Value
TFT	: Toll Fare Indication
TM	: Toll Motorway
TMC	: Toll Monitor Console
TSP	: Total Suspended Particles
ug/m <sup>3</sup>	: Microgram per Cubic Meter
USEPA	: United States Environmental Protection Agency
V/C Ratio	: Volume Capacity Ratio
veh/day	: Vehicle per Day
VOC	: Vehicle Operating Costs
vph	: Vehicle per Hour

## **CHAPTER 1**

### **INTRODUCTION**



# CHAPTER 1

## INTRODUCTION

### 1.1 BACKGROUND

Recently, the economy of Thailand is remarkably growing. However, benefits of the economic growth are exclusively concentrated in Bangkok and its surrounding area while inter-regional disparity of socio-economic level is more and more expanding.

Considering this situation, the Government of the Kingdom of Thailand (the Government of Thailand) took up well-balanced development of the whole nation by decentralizing socio-economic activities from Bangkok metropolitan area, and continuing stable growth of the national economy as one of the most important national policies.

The Government of Thailand inferred that development of a nationwide inter-city motorway network is essential to achieve this policy, and requested the Government of Japan to conduct a master plan study on the inter-city motorway development. This study was carried out by the Japan International Cooperation Agency (JICA) under the title of "The Toll Highways Development Study in the Kingdom of Thailand" from 1990 to 1991 (the Master Plan Study) and proposed a conceptional development plan which is composed of a nationwide inter-city motorway network of 4,300 km in total length.

In the transportation sector plan of the present Seventh National Economic and Social Development Plan (the 7th National Plan), which is in force from 1992 to 1996, development of the inter-city motorway is the most important task to be realized without delay. Based on this basic policy, the Department of Highways (DOH) decided to include the implementation of 4,300 km inter-city motorway network proposed by JICA study in DOH's long term strategic plan of highway development.

Besides, DOH established the Seventh Highway Development Plan (the 7th Highway Plan) in which construction of 198 km motorway is scheduled, and requested the Government of Japan to carry out a feasibility study on two high priority routes selected from the 4,300 km inter-city motorway network. The requested routes include some sections planned to be constructed in the 7th Highway Plan.

In response to the request of the Government of Thailand, the Government of Japan has decided to conduct the Feasibility Study on the Inter-City Toll Motorway Projects in the Kingdom of Thailand (the Study).

JICA, the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, has organized and dispatched the Japanese Study Team (the Study Team) for the Study in accordance with the Scope of Work agreed upon on November 6, 1992 between DOH which acts as the counterpart agency and JICA Preparatory Study Team.

## **1.2 OBJECTIVES OF THE STUDY**

The objectives of the Study are as follows:

- i. To formulate an inter-city toll motorway development plan for the high priority routes in the Kingdom of Thailand. (Feasibility Study)
- ii. To propose the methodologies for implementation and operation of the toll motorways.
- iii. To perform technology transfer to Thai counterpart personnel in the course of the Study.

## **1.3 SCOPE OF THE STUDY**

### **1.3.1 Study Route**

The Study routes, as shown in the location map, are as follows:

Lampang - Doi Saket	98.7 km
Ban Pong - Cha Am	133.7 km
Total	232.4 km

### **1.3.2 Scope of the Study**

In order to achieve the Study objectives mentioned in 1.2, the following tasks will be carried out according to the Study Flow Diagram presented in Figure 1.1:

- Collection and analysis of relevant data
- Establishment of socio-economic framework
- Study of design standard
- Field reconnaissance
- Preparation of alternative routes and selection of optimum route
- Initial environmental examination
- Environmental impact assessment
- Traffic survey
- Forecast of traffic demand
- Natural condition survey
- Topographic survey
- Preliminary design
- Study of operation and maintenance system
- Construction plan
- Estimate of project cost
- Economic and financial analysis
- Preparation of implementation program
- Overall evaluation and recommendation

## **1.4 STUDY SCHEDULE**

The flow diagram in Figure 1.1 shows the Study schedule, in which the Study will be commenced at the end of August 1993 and completed by the beginning of March 1995 with a total time length of 18 months.

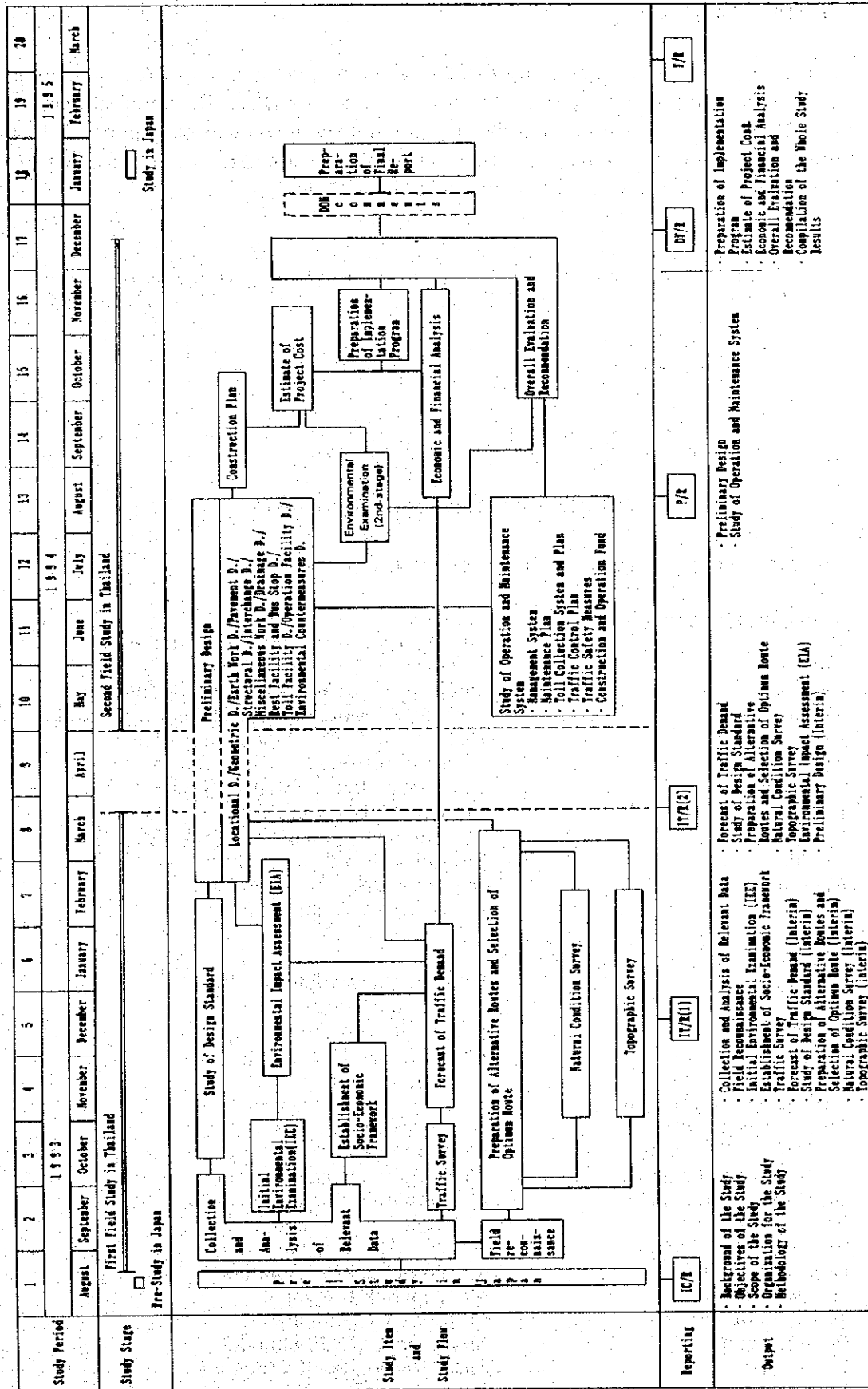


FIGURE 1.1 STUDY FLOW DIAGRAM

## 1.5 ORGANIZATION

The Study will be carried out by the Study Team appointed by JICA in close collaboration with the Counterpart Team organized by the DOH. On commencement of the Study, JICA organized an Advisory Committee composed of experts and Japanese Government officials, to advise the Study Team and review the results of the Study. The organization chart is shown in Figure 1.2.

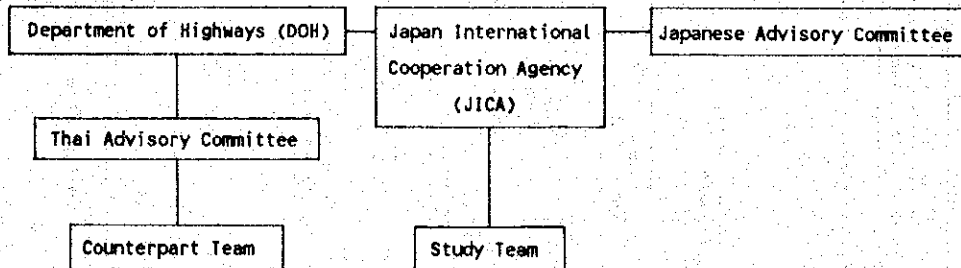


FIGURE 1.2 ORGANIZATION CHART

The members participated in the Study are listed below:

### Thai Advisory Committee

Chairman  
Member  
Member  
Member  
Member  
Member  
Member  
Member  
Member  
Member  
Member  
Secretary

Deputy Director General for Engineering  
Director of Planning Division  
Director of Location and Design Division  
Director of Materials and Research Division  
Director of Traffic Engineering Division  
Director of Road Research Center  
Director of Toll Highway Office  
Mr. Isamu Bito (Aug.'93 - Apr.'94)  
Mr. Shunichi Hamada (Jul.'94 - Mar.'95)  
Mr. Bancha Vadhanasindhu  
Mrs. Phimchai Yuthabandol  
Mr. Sunant Gliengpradit

### Japanese Advisory Committee

Chairman  
Member  
Member  
Project Coordinator

Dr. Kazuaki Miyamoto  
Mr. Koichi Osada  
Mr. Tatsuo Suzuki  
Mr. Toshihisa Hasegawa

### DOH Counterpart Team

Project Coordinator  
Sr. Highway Engineer  
Sr. Structural Engineer  
Sr. Survey Engineer  
Sr. Soil Engineer  
Sr. Highway Engineer  
Highway Engineer  
Traffic Engineer  
Traffic Engineer  
Project Economist  
Economist  
Economist

Mr. Sunant Gliengpradit  
Mr. Wanchai Parkluck  
Mr. Manitchai Glawgitigool  
Mr. Kiatikrai Pramroj  
Mr. Suchart Leerakomsan  
Mr. Chusak Gaywee  
Mr. Somchai Kesasomboon  
Mr. Vanchak Chayakul  
Mr. Chavalit Lupholtae  
Mrs. Phimchai Yuthabandol  
Miss. Nanthanee Kwangsopa  
Miss. Phienphen Chitrakool

### JICA Study Team

Team Leader/Highway Planner	Mr. Masahiko Tohi (Aug.'93 - Jul.'94)
Team Leader/Highway Planner	Mr. Tsuneo Bekki (Mar.'94)
Team Leader/Highway Planner	Mr. Kunihiro Sawano (Jul.'94 - Feb.'95)
Highway Engineer (1)	Mr. Hidetomo Akutsu
Highway Engineer (2)	Mr. Akira Manda
Motorway Facility Planner	Mr. Takashi Shimizu
Structural Engineer	Mr. Toshihisa Kimura
Tunnel Engineer	Mr. Yoshio Nagami
Regional Planner	Mr. Akio Morikawa
Transport Planner	Dr. Hani A. Halim
Traffic Engineer	Mr. Kazuyuki Otsuka
Environmental Specialist	Mr. Hiroshi Kawashima
Soil/Material Engineer	Mr. Toshio Aida
Construction Expert	Mr. Ichizuru Ishimoto
Organization Expert	Mr. Shin Kokubo
Transport Economist	Mr. Masahito Honma
Photogrammetrist	Mr. Takashi Yokokawa
Survey Engineer	Mr. Masashi Suzuki

## 1.6 REPORTING

The following reports were prepared and submitted to DOH during the course of the study:

Inception Report	August 1993
Interim Report (1)	December 1993
Interim Report (2)	March 1994
including MOTORWAY DESIGN STANDARD	
Progress Report	August 1994
Draft Final Report	December 1994

The final report is organized as follows:

Volume I	:	EXECUTIVE SUMMARY
Volume II	:	MAIN TEXT
Volume III	:	APPENDICES
Volume IV	:	DRAWINGS

This report: Volume II, MAIN TEXT, consists of 11 chapters as shown below:

CHAPTER 1 INTRODUCTION gives the background, objectives, scope and organization of the study,

CHAPTER 2 SOCIO-ECONOMIC FRAMEWORK provides present socio-economic characteristics and results of formulating framework up to the year of 2020,

CHAPTER 3 TRAFFIC DEMAND FORECAST gives results of traffic surveys and future traffic forecast,

CHAPTER 4 ROUTE SELECTION presents alternative segments, evaluation and

selected optimum route for each route.

**CHAPTER 5 EVALUATION OF SELECTED ROUTES** discusses mobility and accessibility of the selected routes after presenting salient characteristics of them.

**CHAPTER 6 PRELIMINARY DESIGN** gives preliminary engineering study outputs,

**CHAPTER 7 ENVIRONMENTAL EXAMINATION** gives outcomes of environmental examination under the national policy stipulated in environmental acts in Thailand,

**CHAPTER 8 STUDY ON OPERATION AND MAINTENANCE SYSTEM** presents organization and systems for operation, management and maintenance of toll motorway,

**CHAPTER 9 COST ESTIMATES** gives estimated investment cost and operating/maintenance costs.

**CHAPTER 10 PROJECT EVALUATION** presents economic, financial and technical evaluation of the project including environmental impacts assessment.

**CHAPTER 11 PROJECT IMPLEMENTATION AND RECOMMENDATIONS** discusses implementing issues and implementation program and presents recommendations for smooth implementation of the project.

## **CHAPTER 2**

# **SOCIO-ECONOMIC FRAMEWORK**





## CHAPTER 2

### SOCIO-ECONOMIC FRAMEWORK

Establishment of socio-economic framework aims at preparation of basic data required for the future traffic demand estimation. Population and Gross Provincial Product (GPP) were selected as major items of framework, because they are highly associated to traffic generation and attraction. Target years for the socio-economic framework were set at 1996, 2001, 2011 and 2021. Changwat data were basically prepared as a minimum zone unit for forecasting traffic demand. Changwat population of the Study Routes were broken down into Amphoe population in order to improve the accuracy of traffic forecast.

#### 2.1 SOCIO-ECONOMIC CONDITIONS

##### 2.1.1 Population

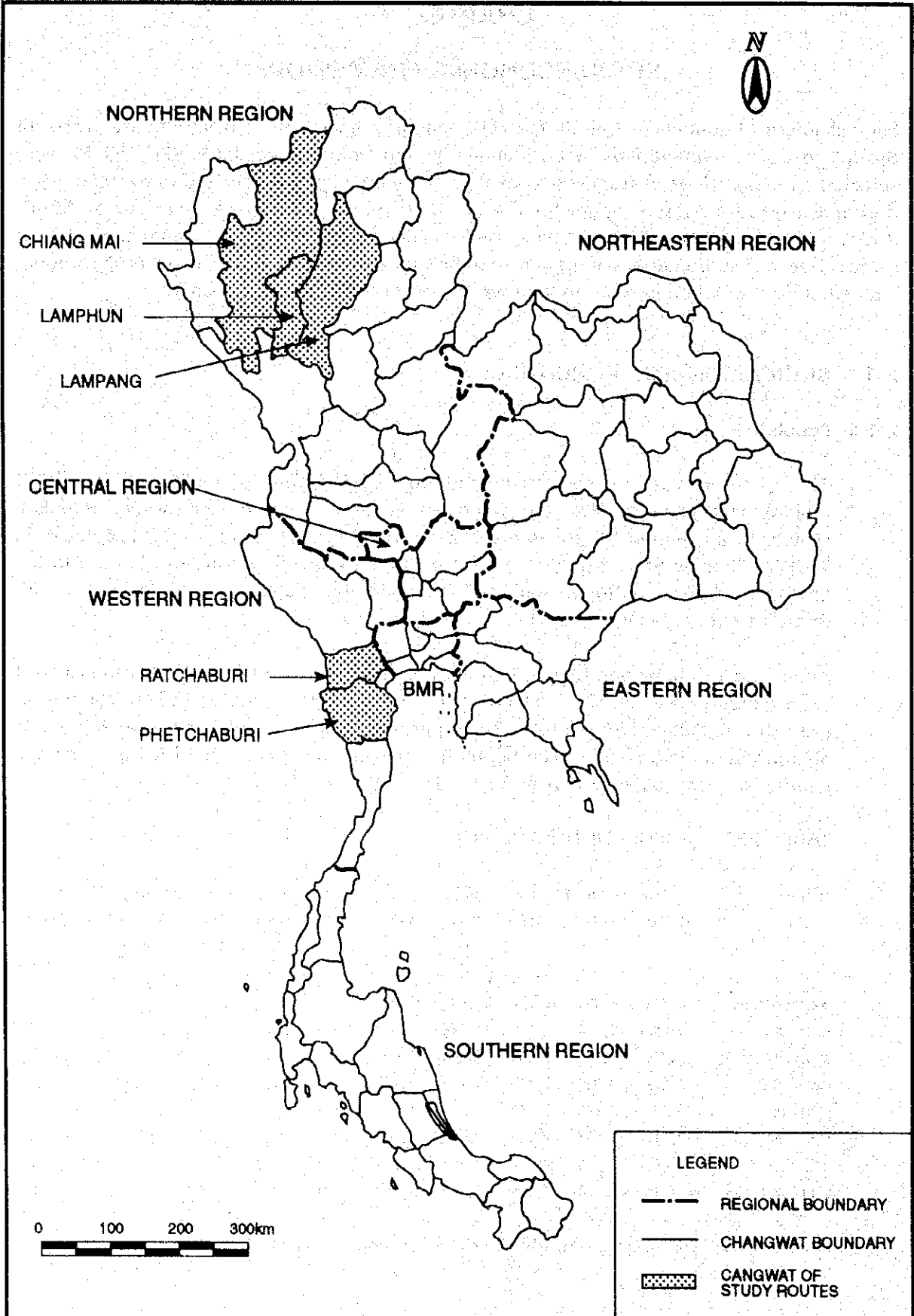
The administrative system of the Kingdom of Thailand is divided into seven(7) regions: Northeastern, Northern, Southern, Eastern, Western, Central, and Bangkok Metropolitan Region (BMR). Regions are divided into 73 Changwats (Provinces in 1992). Changwat of Study Routes are Chiang Mai, Lamphun and Lampang for Lampang - Doi Saket Route, and Ratchaburi and Phetchaburi for Ban Pong - Cha Am Route as shown in Figure 2.1-1.

According to population registration data of the Ministry of Interior, Thailand had a total population in 1992 of 57,789,000 with a growth rate of 1.5%. Population growth in Thailand slowed from 2.0% per annum during 1981-1986 to 1.4% per annum during 1986-1991. The population density in 1992 was 112.6 persons per square kilometer as shown in Table 2.1-1.

TABLE 2.1-1 POPULATION BY REGION

REGION	Population (1,000 persons)					Annual Growth Rate(%)				Density in 1992 persons/m <sup>2</sup>
	1976	1981	1986	1991	1992	1976- 1981	1981- 1986	1986- 1991	1991- 1992	
NORTHEASTERN	14,793	16,394	18,552	20,045	20,059	2.1	2.5	1.6	0.1	118.8
NORTHERN	9,048	9,714	10,490	11,022	11,683	1.4	1.5	1.0	6.0	68.9
SOUTHERN	5,330	5,935	6,608	7,208	7,402	2.2	2.2	1.8	2.7	104.7
EASTERN	2,622	2,945	3,418	3,740	3,739	2.3	3.0	1.8	0.0	102.4
WESTERN	2,604	2,866	3,146	3,337	3,424	1.9	1.9	1.2	2.6	79.5
CENTRAL	2,417	2,557	2,724	2,854	2,822	1.1	1.3	0.9	-1.1	170.1
BMR	6,400	7,465	8,031	8,702	8,661	3.1	1.5	1.6	-0.5	1,116.4
WHOLE KINGDOM	43,213	47,875	52,969	56,907	57,789	2.1	2.0	1.4	1.5	112.6

Source: Registration Division, Department of Local Administration, Ministry of Interior



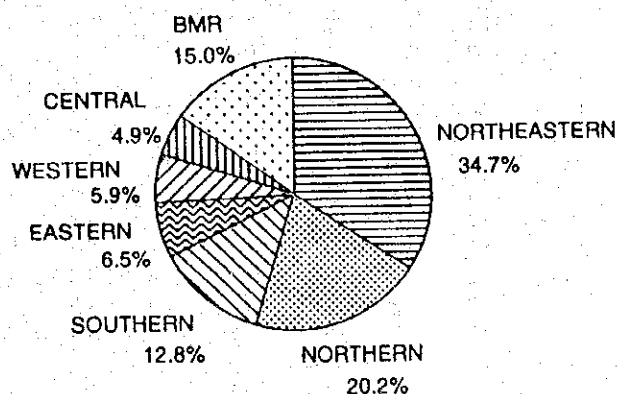
FEASIBILITY STUDY  
ON  
THE INTER-CITY TOLL MOTORWAY PROJECTS

FIGURE 2.1-1  
ADMINISTRATIVE BOUNDARY MAP

Population growth by region during 1991-1992 showed major changes due to the election in 1992. During 1986-1991, Southern and Eastern Regions showed the highest population growth at 1.8 per annum.

Population density in BMR was the highest at 1,116.4 persons per square kilometer. The lowest population density was 68.9 persons per square kilometer in the Northern Region.

Figure 2.1-2 shows the regional distribution of population. The Northeastern Region had the biggest population of 20,059,000 persons with a share of 34.7% followed by the Northern Region with 11,683,000 persons. The Western Region had 3,424,000 persons with a total population share of 5.9%.



Source: Department of Local Administration, Ministry of Interior

FIGURE 2.1-2 POPULATION DISTRIBUTION BY REGION IN 1992

Population by Changwat is shown in Appendix 2.1-1 Bangkok Metropolitan Administration (BMA) showed the biggest population of 5,562,000 persons with a total population share of 9.6%. The population in Chiang Mai, Lampang and Lamphun in the Northern Region is 1,531,000; 776,000 and 398,000, respectively. The population in Ratchaburi and Phetchaburi in the Western Region was 777,000 and 439,000, respectively.

The population density in BMA was also the highest at 3,553.6 persons per square kilometer. Chiang Mai, Lampang and Lamphun in the Northern Region had 76.1, 61.9 and 88.3 persons per square kilometer, respectively. These densities are lower than that of the national average of 112.6 persons per square kilometer. Phetchaburi and Ratchaburi had 70.5 and 149.5 persons per square kilometer, respectively.

Population by Amphoe influenced by the Study Routes is presented in Table 2.1-2. Each Amphoe Muang in Changwat had a larger population than other Amphoes. The population density in Muang Amphoe Chiang mai, Lampang and Lamphun was 1,591; 272; and 190 persons per square kilometer, respectively, while in Muang Amphoe Ratchaburi and Phetchaburi was 423 and 410 persons per square kilometer, respectively.

TABLE 2.1-2 POPULATION BY AMPHOE

LAMPANG - DOI SAKET ROUTE

(1/2)

Amphoe	1976	1981	1986	1991	1992	Annual Growth Rate (%)				Density in 1992 (persons per sq km)
						1976-	1981-	1986-	1991-	
						1981	1986	1991	1992	
CHIANG MAI	1,100.3	1,180.2	1,296.4	1,385.9	1,530.9	1.4	1.9	1.3	10.5	76.1
MUANG CHIANG MAI	166.8	181.2	206.9	216.0	242.4	1.7	2.7	0.9	12.2	1,591.0
CHIANG DAO	43.0	43.8	48.7	52.7	72.3	4.3	2.1	1.6	37.2	38.4
CHOM THONG	73.1	73.3	86.5	90.6	93.6	0.1	3.4	0.9	3.3	96.3
DOI SAKET	52.4	57.9	61.2	63.7	62.4	2.0	1.1	0.8	-2.0	93.0
FANG	98.1	104.3	110.9	83.6	102.8	1.2	1.2	1.3	23.0	124.0
HANG DONG	53.1	55.9	58.3	66.9	62.3	1.0	0.8	2.8	-6.9	224.8
HOT	22.6	31.4	34.7	37.4	40.0	6.8	2.0	1.5	7.0	28.0
DOI TAO	20.6	23.5	25.4	26.8	27.2	2.7	1.6	1.1	1.5	33.8
MAE AI	40.2	41.4	45.7	52.9	74.3	0.6	2.0	3.0	40.5	100.9
MAE CHAEM	33.8	37.9	46.5	51.6	56.4	2.3	4.2	2.1	9.3	16.8
MAE RIM	57.2	59.7	64.9	69.6	75.1	0.9	1.7	1.4	7.9	169.3
MAE TAENG	56.0	59.9	63.2	66.1	77.4	1.4	1.1	0.9	17.1	56.8
OMKOI	20.2	21.5	26.4	30.4	39.5	1.3	4.2	2.9	29.9	18.9
PHRAO	44.3	43.9	47.8	50.3	55.3	-0.2	1.7	1.0	9.9	48.2
SAMOENG	16.8	18.6	20.6	21.6	22.7	2.1	2.1	1.0	5.1	25.3
SAN KAMPHAENG	76.1	79.5	87.9	94.2	93.2	0.9	2.0	1.4	-1.1	145.6
SAN PA THONG	100.4	104.0	105.3	78.8	81.2	0.7	0.2	0.8	3.0	455.7
SAN SAI	64.9	69.6	75.5	82.8	81.8	1.4	1.6	1.9	-1.2	287.0
SARAPHI	60.7	63.7	71.4	74.8	75.7	1.0	2.3	0.9	1.2	776.8
K.A. WIANG HEANG		9.2	8.6	9.6	19.2		-1.3	2.2	100.0	28.6
K.A. CHAI PRAKAN				34.5	46.0				33.3	80.7
K.A. MAE WANG				31.0	30.1				-2.9	50.1
LAMPHUN	339.5	356.2	402.3	417.9	398.0	1.0	2.5	0.8	-4.8	88.3
MUANG LAMPHUN	140.1	147.0	159.0	143.7	132.3	1.0	1.6	0.7	-7.9	272.0
BAN HONG	38.9	40.3	45.4	46.0	45.6	0.7	2.4	0.3	-0.9	76.4
LI	55.3	47.4	57.5	61.0	61.0	2.3	3.9	1.2	0.0	35.8
K.A. THUNG HUA CHANG		14.5	16.2	17.5	17.3		2.2	1.6	-1.1	35.6
MAE THA	32.9	33.3	39.9	42.4	40.0	0.2	3.7	1.2	-5.7	52.5
PA SANG	72.3	73.7	84.3	86.7	83.6	0.4	2.7	0.6	-3.6	239.3
K. A. BAN THI				20.6	18.2				-11.7	148.6
LAMPANG	643.3	665.2	744.6	777.8	776.2	0.7	2.3	0.9	-0.2	61.9
MUANG LAMPANG	177.0	183.7	220.8	231.0	219.8	0.7	3.7	0.9	-4.8	190.0
MAE MO	21.7	23.4	29.8	33.4	35.3		5.0	2.3	5.7	41.3
CHAE HOM	69.4	40.4	42.5	44.1	43.9	0.9	1.0	0.7	-0.5	32.5
HANG CHAT	43.3	44.7	49.6	51.1	53.9	0.6	2.1	0.6	5.5	78.7
KO KHA	61.9	59.5	63.3	65.0	69.4	-0.8	1.2	0.5	6.8	125.9
MAE PHRIK	14.7	15.5	17.0	17.0	17.4	1.1	1.9	0.0	2.4	32.3
MAE THA	62.7	63.9	65.7	68.8	70.2	0.4	0.6	0.9	2.0	76.8
NGAO	43.7	46.4	55.4	59.4	60.7	1.2	3.6	1.4	2.2	33.4
SOEM NGAM	28.6	29.4	31.2	31.8	33.4	0.6	1.2	0.4	5.0	52.9
SOP PRAP	25.4	25.9	27.3	28.1	28.4	0.4	1.1	0.6	1.1	56.5
THOEN	53.2	55.8	58.1	60.1	62.7	1.0	0.8	0.7	4.3	38.4
WANG NUA	41.7	44.3	52.4	54.8	46.9	1.2	3.4	0.9	-14.4	45.3
MUANG PAN		32.3	31.5	33.2	34.2		-0.5	1.1	3.0	39.5

**BAN PONG - CHA AM ROUTE**

Amphoe	1975	1981	1986	1991	1992	Annual Growth Rate (%)				Density in 1992 (persons per sq km)
						1976-1981	1981-1986	1986-1991	1991-1992	
RATCHABURI	597.0	653.6	691.6	727.2	777.2	1.8	1.1	1.0	6.9	149.6
MUANG RATCHABURI	137.4	155.6	163.5	174.3	181.9	2.5	1.0	1.3	4.4	422.7
BAN PONG	123.2	131.2	134.9	143.4	153.6	1.3	0.6	1.2	7.1	419.0
BANG PHAE	37.4	38.7	38.9	40.8	43.1	0.7	0.1	1.0	5.6	249.7
CHOM BUNG	35.9	42.5	48.1	50.1	56.7	3.4	2.5	0.8	13.2	73.4
SUAN PHUNG	19.1	30.1	37.3	40.4	48.3	9.5	4.4	1.6	19.6	23.8
DAMNOEN SADUAK	92.5	92.7	94.3	95.6	101.5	0.0	0.3	0.3	6.2	482.7
PAK THO	41.0	45.1	48.7	51.2	60.1	1.9	1.5	1.0	17.4	79.3
PHOTHARAM	99.8	106.4	114.5	120.3	120.5	1.3	1.5	1.0	0.2	289.0
WAT PHLENG	10.7	11.3	11.4	11.1	11.5	1.1	0.2	-0.5	3.6	303.5
PHETCHABURI	345.2	372.3	412.3	430.8	438.6	1.5	2.1	0.9	1.8	70.5
MUANG PHETCHABURI	96.6	101.8	109.2	111.6	116.4	1.1	1.4	0.4	4.3	410.0
BAN LAEM	49.7	51.6	56.4	58.8	58.1	0.8	1.8	0.8	-1.2	306.0
BAN LAT	42.5	43.0	48.3	50.0	49.6	0.2	2.4	0.7	-0.8	166.4
CHA-AM	39.5	44.3	51.5	56.8	58.4	2.3	3.1	2.0	2.8	88.4
KHAO YOI	34.5	37.4	36.0	37.5	37.2	1.6	-0.8	0.8	-0.8	121.7
NONG YA PLONG	7.6	10.2	10.5	11.3	11.5	6.1	0.6	1.5	1.8	9.2
THA YANG	74.8	84.0	100.4	80.8	86.1	2.3	3.6	0.9	6.6	116.9
K.A. KAENG KRACHAN				24.0	21.3				-11.2	8.5

Source: Registration Division, Department of Local Administration, Ministry of Interior

**2.1.2 Economic Indices**
**1. GDP**

In 1991, the Gross Domestic Product (GDP) amounted to 2,509 billion Baht at current market prices and to 2,108 billion Baht at 1988 constant prices as shown in Table 2.1.3. The GDP growth rate of 10.9% per annum during 1986-1991 was higher than the growth rate during the Fifth Plan, 1981 - 1986, of 5.4%.

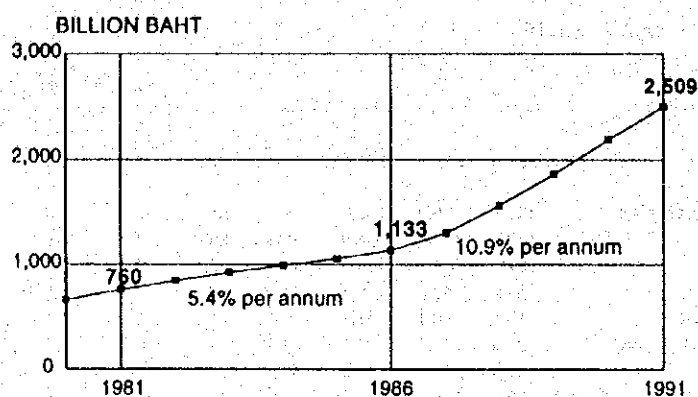
From 1987, Thailand's economy turned up due to an increase in exports and an influx of foreign investment, as shown in Figure 2.1-3.

Per capita GDP increased 2.8 times from 15,934 Baht in 1981 to 44,085 Baht in 1991, as shown in Table 2.1-3. The average annual growth rate of per capital GDP during 1981-1986 and 1986-1991 were 3.4% and 9.1%, respectively.

**TABLE 2.1-3 GROSS DOMESTIC PRODUCT**

	1981	1986	1991
GDP at current market prices (Million Baht)	760,356	1,133,397	2,509,427
GDP at 1988 constant prices (Million Baht)	967,706	1,257,177	2,108,249
GDP growth rate (% per annum)		5.4	10.9
Per capita GDP at current market prices (Baht)	15,934	21,584	44,085
Per capita GDP at 1988 constant prices (Baht)	20,280	23,942	37,037
Per capita GDP growth rate (% per annum)		3.4	9.1

Source: National Income of Thailand, Rebase Series 1980-1991, NESDB



Source: National Income of Thailand, Rebase Series 1980 - 1991, NESDB

FIGURE 2.1-3 GDP AT CURRENT MARKET PRICES

The share of the agricultural sector decreased from 21.4% in 1981 to 12.8% in 1991, The manufacturing sector grew steadily and expanded its share from 22.6% in 1981 to 28.2% in 1991 in terms of current prices, as shown in Table 2.1-4.

TABLE 2.1-4 GDP BY SECTOR

Sector	1981 (% Share)	1986 (% Share)	1991 (% Share)
Agriculture	21.4	15.7	12.8
Mining and Quarrying	1.5	1.7	1.6
Manufacturing	22.6	23.9	28.2
Construction	4.6	4.9	6.8
Electricity and Water Supply	1.4	2.5	2.1
Transportation and Communication	5.5	7.8	7.0
Wholesale and Retail Trade	18.2	16.8	17.0
Banking, Insurance and Real Estate	2.9	3.3	5.4
Ownership of Dwellings	3.5	4.2	2.9
Public Administration and Defence	4.4	4.5	3.4
Services	14.1	14.7	12.9
GDP	100.0	100.0	100.0

Source: National Income of Thailand, Rebase Series 1980-1991, NESDB

## 2. GRP

Table 2.1-5 shows Gross Regional Product (GRP) share. In 1989, the Northern and Western Regions shared 11.4% and 5.2% of the nation's GDP, respectively. GRP at 1988 constant prices is currently under estimation by NESDB. GRP at 1972 constant prices is shown in Table 2.1-6. The growth rate of GRP in the Northern Region during 1986-1989 was 7.7% per annum, while that of the Western Region was 8.7% per annum. These growth rates are somewhat lower than the average of 11.6% per annum during the same period.

Per capita GRP in BMR was the largest at 96,239 Baht in 1989 followed by the Eastern Region at 45,751 Baht at current market prices. Per capita GRP in the Northern Region was 18,833 Baht and Western Region 28,434 Baht, which were lower than the per capita average GRP as shown in Figure 2.1-4.

TABLE 2.1-5 GRP SHARE

REGION	1981 (% Share)	1986 (% Share)	1989 (% Share)
NORTHEASTERN	14.7	14.4	12.9
NORTHERN	13.5	12.2	11.4
SOUTHERN	10.2	9.8	9.1
EASTERN	7.7	8.7	8.6
WESTERN	6.4	5.5	5.2
CENTRAL	5.3	4.6	4.6
BMR	42.3	44.8	48.1
TOTAL	100.0	100.0	100.0

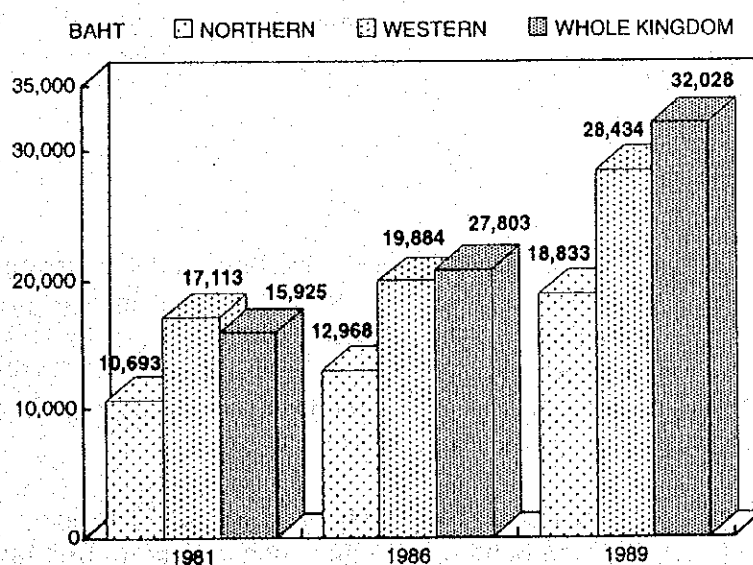
Source: Gross Regional and Products, Preliminary Series 1981-1989, NESDB

TABLE 2.1-6 GRP AT 1972 CONSTANT PRICES

REGION	1981	1986	1989	GROWTH RATE (% p.a.)	
	(Million Baht)	(Million Baht)	(Million Baht)	1981-1986	1986-1989
NORTHEASTERN	49,279	65,411	81,190	5.8	7.5
NORTHERN	42,744	54,628	68,286	5.0	7.7
SOUTHERN	30,827	40,592	52,804	5.7	9.2
EASTERN	22,577	30,412	44,220	6.1	13.3
WESTERN	18,634	24,305	31,201	5.5	8.7
CENTRAL	16,920	20,115	26,798	3.5	10.0
BMR	137,458	178,027	269,697	5.3	14.8
TOTAL	318,439	413,490	574,195	5.4	11.6

Source: Gross Regional and Provincial Products, Preliminary Services 1981-1989, NESDB

Table 2.1-7 shows GRP by sector in 1989. Agriculture was the major economic sector in the Northern, Western, Northeastern and Southern Regions. The agriculture sector's share in the Northern Region was 30.9% of total GRP while that in the Western Region was 26.1%, which are higher with that of the nation's GDP.



Source: Gross Regional and Provincial Products, Preliminary Series 1981 - 1989, NESDB

FIGURE 2.1-4 PER CAPITA GRP

**TABLE 2.1-7 GRP BY SECTOR IN 1989**

Sector	NORTHEASTERN	NORTHERN	SOUTHERN	EASTERN
Agriculture	27.5	30.9	32.9	14.7
Mining and Quarrying	2.2	5.5	5.2	7.8
Manufacturing	7.5	7.5	5.4	26.9
Construction	6.4	5.8	5.8	6.9
Electricity and Water Supply	1.6	1.7	2.0	2.3
Transportation and Communication	4.5	5.0	6.1	5.7
Wholesale and Retail Trade	22.2	17.5	18.6	13.3
Banking, Insurance and Real Estate	2.8	3.5	3.4	3.1
Ownership of Dwellings	6.6	4.7	3.5	2.5
Public Administration and Defence	6.5	5.2	4.8	2.8
Services	12.3	12.6	12.3	13.9
GRP	100.0	100.0	100.0	100.0

Sector	WESTERN	CENTRAL	BMR	TOTAL
Agriculture	26.1	18.8	3.0	15.0
Mining and Quarrying	7.2	15.2	0.6	3.4
Manufacturing	15.2	19.6	39.9	25.5
Construction	5.6	3.3	6.8	6.3
Electricity and Water Supply	2.3	3.6	2.7	2.3
Transportation and Communication	5.7	4.7	8.8	6.9
Wholesale and Retail Trade	18.3	15.4	12.5	15.4
Banking, Insurance and Real Estate	3.4	2.7	6.9	4.9
Ownership of Dwellings	3.6	3.4	2.1	3.3
Public Administration and Defence	4.1	5.0	2.2	3.6
Services	8.7	8.4	14.7	13.3
GRP	100.0	100.0	100.0	100.0

Source : Gross Regional and Provincial Products, Preliminary Series 1981-1989, NESDB

### 3. GPP

Gross Provincial Product (GPP) at 1988 constant prices is also under preparation by NESDB. Figure 2.1-5 shows GPP in 1989 at current market prices. Bangkok Metropolitan had the highest GPP at 628,033 million Baht in 1989 with a share of 35.4% the national GDP (Appendix 2.1-2). Based on GPP at 1972 constant prices, the GPP growth rate in Bangkok Metropolitan during the same period was 12.1% per annum as shown in Appendix 2.1-3.

GPP in Chiang Mai, Lampang and Lamphun was 33,481 Million Baht, 15,905 Million Baht, and 6,503 Million Baht with average annual growth rate during 1986-1989 of 4.8%, 4.1%, and 5.2%, respectively. GPP in Ratchaburi and Petchaburi was 29,285 Million Baht and 11,218 Million Baht, with average annual growth rates during 1986-1989 4.2% and 5.0%, respectively.



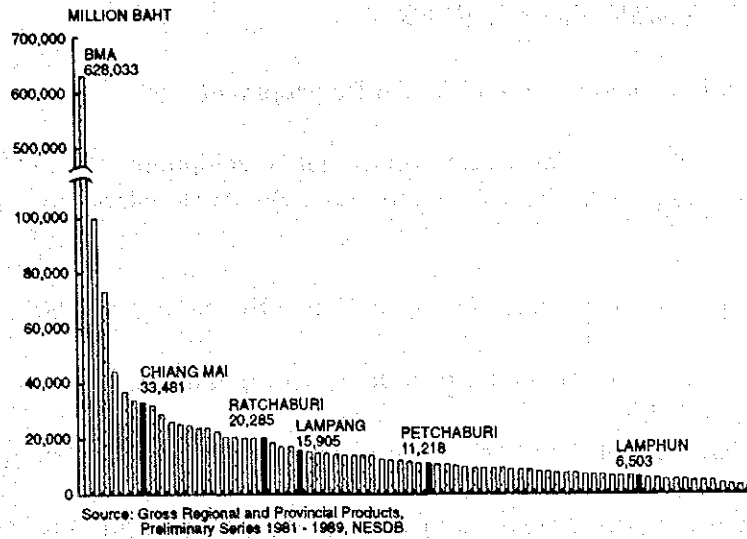


FIGURE 2.1-5 GPP IN 1989 AT CURRENT MARKET PRICES

Figure 2.1-6 shows per capita GPP of the study routes. In 1989, Chiang Mai in the Northern Region was 24,727 Baht followed by Lampang was 21,039 Baht and Lamphun with 15,861 Baht. In the Western Region, Ratchaburi had 28,733 Baht and Petchaburi 26,709 Baht, higher than the Northern Region. However, compared with national per capita GDP of 32,028 Baht, that of each Changwat was lower.

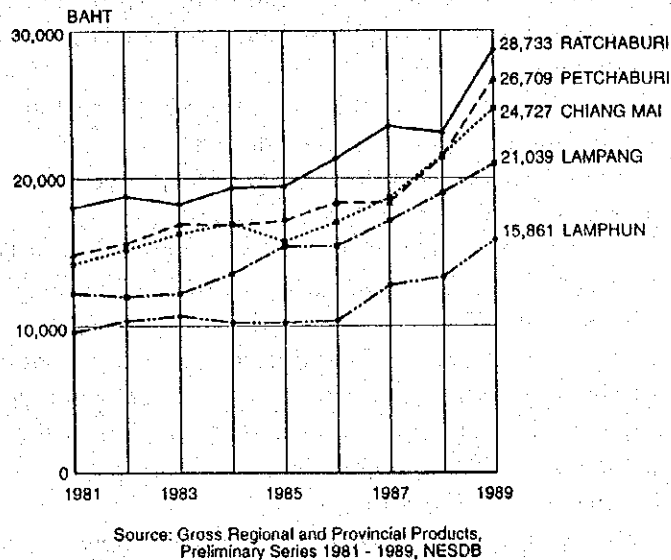


FIGURE 2.1-6 PER CAPITA GPP AT CURRENT MARKET PRICES

Based on GPP by sector, Chiang Mai depend much more on services than on agriculture. The share of services was 22.6% and the average annual growth rate during 1986-1989 was 9.2%. Lampang depend on mining and quarrying, and on wholesale and retail trade, which share 18.8% and 17.6%, respectively. Lamphun depends on agriculture (26.5%) followed by wholesale and retail trade (19.5%). The share of manufacturing in Ratchaburi was 23.0%, followed by agriculture (18.1%) and wholesale and retail trade (16.2%). The share of wholesale and retail trade in Petchaburi was 21.7%, followed by agriculture (17.3%), as shown in Appendix 2.1-4 and 2.1-5.

## **2.2 SOCIO-ECONOMIC FRAMEWORK**

### **2.2.1 Seventh National Economic and Social Development Plan**

The Seventh National Economic and Social Development Plan (1992-1996) is the currently authorized National Economic and Social Development Plan presented by NESDB.

The main development objectives of the Seventh Plan are as follows:

- Maintain economic growth rates at appropriate levels to ensure sustainability and stability.
- Redistribute income and decentralize development to the regions and rural areas more widely.
- Accelerate the development of human resources, and upgrade the quality of life, the environment and natural resource management.

In order to attain the three development objectives, quantitative and qualitative targets of the Seventh Plan are set as follows. Summaries of the figures are shown in Table 2.2-1.

- Set overall economic growth rates at 8.2% per year.
- Increase per capita income to increase from 41,000 baht per person in 1991 to 71,000 baht by the end of the Seventh Plan with an income growth rate of 7% per year in real terms.
- Grow the agricultural sector at no less than 3.4% per year.
- Grow the industrial sector at 9.5% per year.
- Maintain the inflation rate at less than 5.6% per year.
- Keep the trade deficit within 9.4% of GDP.
- Reduce the current account deficit to less than 2.5% of GDP by 1996.
- Reduce the proportion of the poor from 23.7% under the poverty line in 1988 to less than 20% by 1996.
- Reduce income disparities among different groups of people.
- Reduce population growth rate to less than 1.2% per year, which will bring the population of Thailand to 61 million by the end of the Seventh Plan.
- Improve the quality of the population.
- Expand employment opportunities.
- Improve the basic health conditions of all the people.
- Designate the national forest reserve area at 25% of the total land area.
- Reduce pollution levels in water, air, noise, solid wastes and toxic chemicals.

In order to attain the objectives and targets, the following guidelines have been formulated:

1. Guidelines for sustaining economic growth rate at an appropriate level and with stability.
  - Implement fiscal and monetary policies and capital market development.
  - Restructure the agricultural sector to increase productivity and to produce

- high value products which have high market demand.
- Develop the industrial, trade and investment sectors, emphasizing the creation of opportunities for Thai nationals to compete in investment and business activities in foreign countries.
  - Encourage the development and application of appropriate science and technology to increase productivity and improve the quality of export products to enhance the competitiveness of Thai exports.
  - Provide an adequate amount of energy to meet the demand of various sectors of the economy by developing more domestic sources of energy.
  - Speed up investment in the provision of infrastructure services to ensure an adequate high quality supply to meet the increasing demand from economic growth.
  - Promote the development of the Bangkok Metropolitan Region to ensure better connection and integration of Bangkok Metropolis with the Eastern Seaboard Area to serve as the principal economic base of the Metropolitan Region and to stimulate international competitiveness of the Thai economy.
2. Guidelines for the redistribution of income and development to the regions and rural areas.
- Implement monetary, fiscal and capital market development policies to genuinely support the redistribution of income and development benefits to the regions and rural areas.
  - Disperse property ownership to enable those in the agriculture sector to have legal ownership of the land or to have security on farm land.
  - Carry out agricultural restructuring and disperse industries and services to the regions.
  - Develop regional centers to serve as economic and employment bases in each region to take advantage of the decentralization policy of economic activities to the regions.
  - Upgrade the quality of life of rural people, emphasizing the decentralization of government authority to the regions and local level.
  - Develop and upgrade the quality of life of the urban poor.
3. Guidelines for the development of human resources, quality of life and environment.
- Develop human resources, education and health in support of national economic and social development.
  - Cultivate spiritual, cultural and moral development to enable the people to properly adapt themselves to the changing situation and to serve as an important force in national development.
  - Develop environmental quality hand in hand with national economic and social development by emphasizing development management mechanisms to deal with pollution problems in water, air, solid and hazardous wastes in a more efficient manner.
  - Improve the administrative system of natural resources to serve as a basic means of livelihood for rural people, as a national heritage and as an important basis for sustainable development.

4. Guidelines for the development of laws, state enterprises and the bureaucratic system.

- Amend laws to be consistent with the direction and process of development by setting up an independent and non-partisan organization under the law to reform and amend laws which are obstacles to development administration.
- Increase the efficiency of state enterprises by reducing the supervisory role of the government, and improve the legal framework and rules and regulations to ensure more flexibility to state enterprises.
- Improve the bureaucratic system by improving the organizational structure and the government management system.

TABLE 2.2-1 MAJOR DEVELOPMENT TARGETS DURING THE 7TH PLAN (1/2)

	Sixth Plan, Actual (1987-1991)	Seventh Plan Targets (1992-1996)
1. Economic Growth (% per year at constant prices)	10.5	8.2
1.1 Agricultural sector	3.4	3.4
1.2 Non-agricultural sector	12.1	8.6
- Industry	13.7	9.5
- Construction	18.7	8.9
- Services and others	11.0	8.1
2. Per capita income (baht/year)	41,000	71,000
3. Expenditures (% per year at constant prices)		
3.1 Private sector		
- Consumption	9.1	5.7
- Investment	26.0	8.8
3.2 Public sector		
- Consumption	2.0	3.3
- Investment	6.5	8.5
4. Export of goods		
4.1 Average value (billion baht)	496.0	1,063.0
4.2 Average growth rate per year (%)	24.5	14.7
5. Import		
5.1 Average value (billion baht)	664.3	1,358.0
5.2 Average growth rate per year (%)	32.6	11.4
6. Trade balance		
6.1 Average value (billion baht)	-168.0	-313.0
6.2 Average growth rate per year (%)	-8.4	-9.4
7. Income from tourism		
7.1 Average value (billion baht)	91.5	185.0
7.2 Average growth rate per year (%)	27.5	13.3

**TABLE 2.2-1 MAJOR DEVELOPMENT TARGETS DURING THE 7TH PLAN (2/2)**

	Sixth Plan, Actual (1987-1991)	Seventh Plan Targets (1992-1996)
8. Current account balance		
8.1 Average value (billion baht)	-99.0	-170.3
8.2 Current account balance/GDP (%)	-4.9	-5.2
9. Inflation (%)	4.7	5.6
10. Commercial energy production (thousand barrels of crude oil/day)	289.0	410.0
11. Dependancy ratio on foreign energy (%)	60	60
12. Ratio of telephone lines per 100 population	3.6	10
13. Population (million)	56.9	61
Population growth rate (%)	1.4	1.2
14. Transition rate to secondary schools (%)	46.2	73
15. Employment (million persons)	32.0	34.9
Unemployment rate (%)	0.6	0.5
16. Infant mortality rate (per 1,000 live births)	29	23
17. Proportion of people under poverty line (%)	23.7	20
18. Reserve forest (% of total)	18.4	25
19. Control of noise level not to exceed (decibels)		85
20. Limited emission of hazardous wastes from commercial energy consumption compared with 1990		
- Lead level from vehicles	1,030	300
- Carbon monoxide from vehicles (thousand tons)	950	750
- Sulphur dioxide (thousand tons)	840	860
- motor vehicles	100	50
- electricity generation	535	620
- industry and others	205	190

Source : The Seventh National Economic and Social Development Plan (1992-1996)

As for transport sector, the following targets for development of infrastructure services during the Seventh Plan period have been proposed:

- Increase capability and efficiency of the transport sector to provide services which are convenient, rapid, safe and at lower costs, to support development of other sectors and enhance international competitiveness of the Thai economy to ensure appropriately high sustained economic growth.
- Utilize the transport sector as accelerator or catalyst of development, leading to dispersion of development benefits to the regions and a better quality of life of the people.
- Emphasize safety and quality of land, sea and air environmental conditions.

In order to achieve the above targets of transport sector, the following development guidelines are provided:

1. Solution of traffic congestion problems and organization of urban transport system.

- Speed up construction of ringroads around the city and alternative routes bypassing the city.
- Speed up construction of secondary roads in the outskirts of Bangkok Metropolis.
- Construct a central passenger transit center with an integrated network connecting all modes of travel.
- Speed up construction of elevated rail tracks, mass transit rail, community rail and expressway services.
- Enforce restrictive measures and organization of traffic system to reduce use of private passenger vehicles.
- Construct public truck depots in appropriate locations.
- Encourage passenger transport services along the Chao Phraya river and other interconnected canals in Bangkok Metropolis and other vicinity towns in a systematic manner.
- Improve organization and mechanism related to the solution of traffic problems.
- Promote public and private sector cooperation to alleviate environmental problems.

2. Land transport

- Develop networks of inter-urban expressways, or special highways with controlled entries and exits.
- Develop transportation by road, high speed rail and pipeline systems.
- Develop road and rail networks to respond to the demand of the expanding industrial and agricultural sectors.

## 2.2.2 Zonal Framework

### 1. Population

Future population is formulated on the basis of past trends in population increase and "The Population Projection for Thailand 1980-2015", prepared by a working group on population projection, NESDB, which made a long term population projection in order to formulate a basis for economic and social development planning.

According to that projection, the growth rate for 1991-1996 is 1.4% per annum. The growth rates of the later years of 1996-2001 and 2001-2011 are projected also by NESDB as 1.2% and 0.9 % per annum, respectively. Comparing with the target population growth in the 7th plan of 1.2% per annum projected growth rate is higher at 16.7% . .

Hence, in this study, population growth during 1996-2001 and 2001-2011 were modified to decrease in the same proportion. During 2011-2021 population growth was estimated by means of extrapolation, as shown in Table 2.2-2.

TABLE 2.2-2 POPULATION GROWTH RATES (Unit: % per Annum)

	1991-1996	1996-2001	2001-2011	2011-2021
Annual Growth Rate	1.2	1.0	0.8	0.7

On the basis of the above growth rates, the total population was estimated, as shown in Figure 2.2-1.

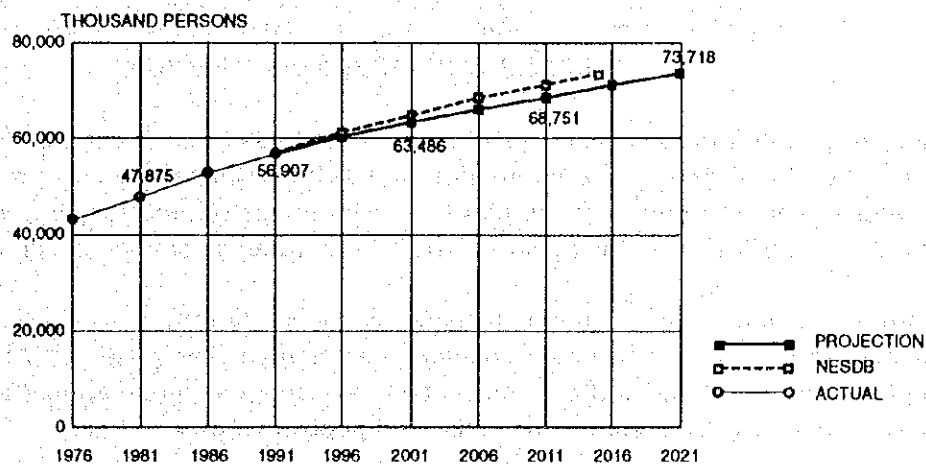
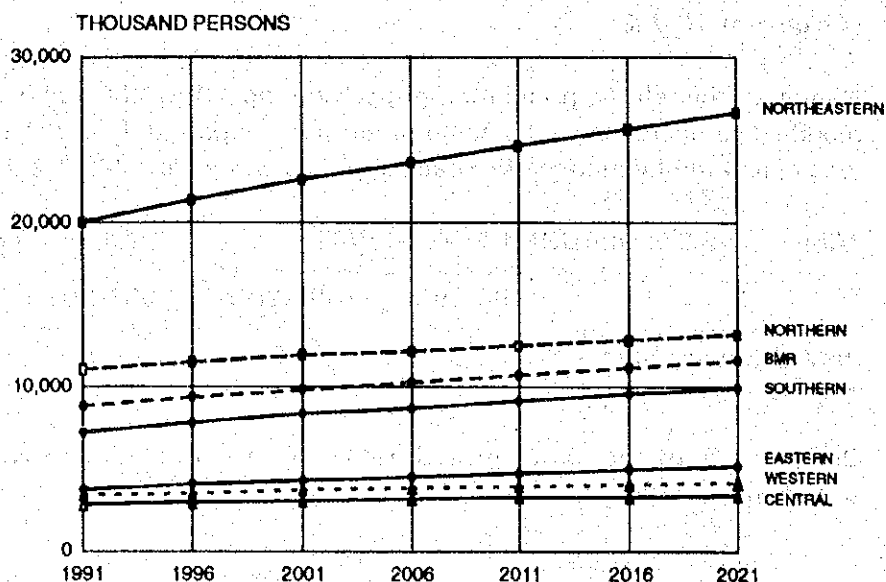


FIGURE 2.2-1 POPULATION PROJECTION

With population growth targeted to decrease in the 7th Plan from 1.4% per annum during the 6th Plan period (1986-1991) to 1.2% per annum, regional population growth was assumed to decrease in the same proportion. Growth for future years beyond 1996 was estimated in the same manner as estimating growth until 1996. Population by region was calculated on the basis of the above assumed growth rates and the population in 1991, as shown in Table 2.2-3 and Figure 2.2-2.

**TABLE 2.2-3 FUTURE POPULATION BY REGION**

REGION	POPULATION(thousand persons)					GROWTH RATES(percent per annum)			
	1991	1996	2001	2011	2021	1991-1996	1996-2001	2001-2011	2011-2021
WHOLE KINGDOM	56,907	60,404	63,486	68,751	73,718	1.2	1.0	0.8	0.7
NORTHEASTERN	20,045	21,398	22,594	24,644	26,585	1.3	1.1	0.9	0.8
NORTHERN	11,022	11,471	11,857	12,501	13,089	0.8	0.7	0.5	0.5
SOUTHERN	7,208	7,759	8,251	9,102	9,917	1.5	1.2	1.0	0.9
EASTERN	3,740	4,027	4,282	4,724	5,147	1.5	1.2	1.0	0.9
WESTERN	3,337	3,502	3,646	3,888	4,112	1.0	0.8	0.6	0.6
CENTRAL	2,854	2,958	3,047	3,194	3,328	0.7	0.6	0.5	0.4
BMR	8,702	9,289	9,808	10,698	11,541	1.3	1.1	0.9	0.8



**FIGURE 2.2-2 POPULATION BY REGION**

Future population by Changwat was calculated based on past trends during the period of 1976-1991. The population in 1992 by Changwat was omitted due to major changes caused by the election. Changwat population was modified by means of population in the region as the control total, as shown in Appendix 2.2-1.

Future population by Amphoe influenced by the study routes was calculated in the same manner as the Changwat population estimation. The predicted Amphoe population was modified by the same means as Changwat population as the control total. Appendix 2.2-2 shows the estimated population by Amphoe.

**2. GDP, GRP and GPP**

According to the 7th Plan, the overall economic growth rate is set at 8.2% per year which is lower than the actual economic growth rate of 10.5% during the 6th Plan period to maintain economic growth rates at appropriate levels. Table 2.2-4 shows GDP and GRP growth rates up to 2011, as prepared by NESDB.



**TABLE 2.2-4 GRP GROWTH AND GDP SHARE**

REGION	GRP GROWTH (% per annum)				GDP SHARE (%) in 1991
	1991-1996	1996-2001	2001-2006	2006-2011	
WHOLE KINGDOM	8.2	7.9	7.0	6.8	100.00
NORTHEASTERN	5.9	5.9	5.7	6.1	13.13
NORTHERN	5.8	6.0	5.7	6.2	11.88
SOUTHERN	6.6	6.5	6.0	6.4	8.78
EASTERN	12.9	11.0	8.5	7.2	8.59
WESTERN	8.5	7.8	6.8	6.5	5.35
CENTRAL	8.3	8.2	7.1	6.9	4.69
BMR	8.7	8.2	7.3	7.1	48.38

Source: NESDB

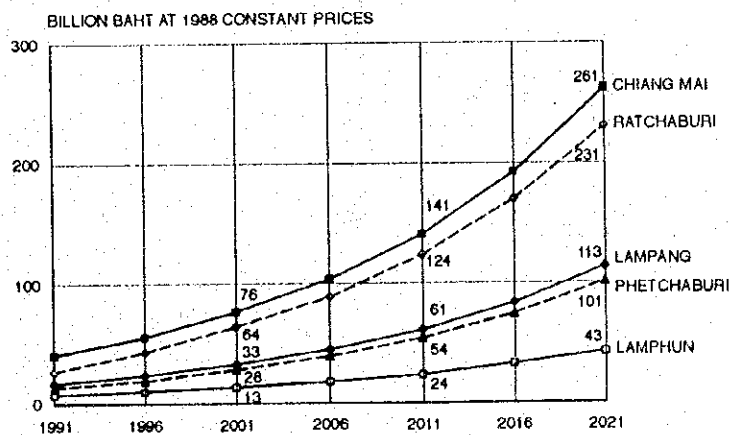
As GRP in 1991 at 1988 constant prices are currently under estimation by NESDB, they were calculated in this study based on the GDP share by region in 1991. GRP at 1988 constant prices up to 2021 was calculated on the basis of GRP in 1991 and GRP growth rates. GDP and GRP growth rates beyond the year 2011 were estimated by means of extrapolation. The results of calculation are shown in Table 2.2-5.

**TABLE 2.2-5 GRP PROJECTION**

(Unit: Billion Baht at 1988 constant prices)

REGION	1991	1996	2001	2011	2021	GROWTH RATES(percent per annum)			
						1991-1996	1996-2001	2001-2011	2011-2021
WHOLE KINGDOM	2,108	3,126	4,572	8,911	16,728	8.2	7.9	6.9	6.5
NORTHEASTERN	277	368	491	868	1,523	5.9	5.9	5.9	5.8
NORTHERN	234	309	414	736	1,302	5.8	6.0	5.9	5.9
SOUTHERN	185	255	349	635	1,145	6.6	6.5	6.2	6.1
EASTERN	181	332	559	1,188	2,299	12.9	11.0	7.8	6.8
WESTERN	113	169	247	469	852	8.5	7.8	6.6	6.2
CENTRAL	99	147	218	429	808	8.3	8.2	7.0	6.5
BMR	1,020	1,546	2,294	4,586	8,799	8.7	8.2	7.2	6.7

GPP by Changwats of Study Routes during 1996-2021 were calculated in same manner as the GRP estimation by using GPP in 1991 and GPP growth rates as shown in Figure 2.2-3.



**FIGURE 2.2-3 GPP PROJECTION**

GPP in 1991 were calculated based on the GRP share by Changwat in 1991. GPP growth rates by Changwat up to 2011 were also prepared by NESDB, as shown in Table 2.2-6. GPP beyond the year 2011 were estimated by means of extrapolation. Appendix 2.2-3 shows GPP by Changwat in detail.

TABLE 2.2-6 GPP GROWTH RATES BY CHANGWAT

CHANGWAT	1991-	1996-	2001-	2006-		CHANGWAT	1991-	1996-	2001-	2006-
	1996	2001	2006	2011			1996	2001	2006	2011
NORTHEASTERN	5.9	5.9	5.7	6.1		EASTERN	12.9	11.0	8.5	7.2
KHON KAEN	5.8	5.9	5.8	6.4		CHONBURI	14.4	11.5	8.9	7.1
UDON THANI	5.6	5.7	5.6	6.3		CHACHOENGSAO	13.3	11.0	8.8	7.0
LOEI	5.0	5.2	5.0	5.8		RAYONG	12.6	11.7	8.3	7.6
NONG KHAI	5.2	5.3	5.3	5.9		TRAT	12.5	12.0	7.4	7.4
MUKDAHAN	5.6	5.7	5.6	6.0		CHANTHABURI	12.2	11.7	7.7	7.7
NAKHON PANOM	5.3	5.4	5.2	5.9		NAKHON NAYOK	6.3	6.8	6.1	6.9
SAKON NAKHON	5.3	5.5	5.3	6.1		PRACHIN BURI	6.5	6.8	6.2	6.5
KALASIN	5.8	5.8	5.6	6.0		WESTERN	8.5	7.8	6.8	6.5
ROI ET	5.6	5.7	5.6	6.0		RATCHABURI	9.7	8.4	7.0	8.8
MAHA SARAKHAM	5.7	5.7	5.6	6.0		KANCHANABURI	8.7	7.9	6.8	6.4
NAKHON RATCHASIMA	6.5	6.5	6.0	6.3		PRACHUP KHIRI KHAN	7.5	7.0	6.2	6.4
CHAIYAPHUM	6.1	6.1	5.7	5.9		PHETCHABURI	8.1	7.6	6.6	6.9
YASOTHON	5.6	5.7	5.6	6.1		SUPHANBURI	8.1	7.6	6.5	6.4
UBON RATCHATHANI	5.7	5.8	5.8	6.2		SAMUT SONGKHRAM	8.1	7.9	8.2	6.0
SI SA KET	5.7	5.7	5.6	6.0		CENTRAL	8.3	8.2	7.1	6.9
BURIRAM	6.4	6.3	5.8	6.1		SARABURI	10.7	9.7	7.9	7.0
SURIN	6.6	6.5	5.9	6.2		SINGBURI	5.7	6.1	5.8	6.4
NORTHERN	5.8	6.0	5.7	6.2		CHAINAT	5.0	5.4	5.3	6.0
CHIANG MAI	6.6	6.8	6.0	6.8		ANG THONG	7.1	7.4	6.6	6.9
LAMPANG	6.8	6.8	6.2	6.8		LOPBURI	5.4	5.7	5.6	6.2
MAEHONGSORN	5.2	5.7	5.2	6.0		AYUTTHAYA	8.5	8.5	7.3	7.3
CHIANG RAI	5.3	5.7	5.3	6.3		BMR	8.7	8.2	7.3	7.1
PHRAE	5.8	6.0	5.7	6.2		BANGKOK	8.5	8.0	7.2	7.1
LAMPHUN	5.7	6.0	5.6	6.4		SAMUT PRAKARN	8.7	8.2	7.6	6.7
NAN	5.4	5.6	5.4	5.9		PATHUM THANI	10.3	9.6	8.3	7.0
PHAYAO	5.1	5.6	5.2	6.2		SAMUT SAKHON	9.6	9.2	8.0	7.2
TAK	6.1	6.2	5.9	6.0		NAKHON PATHOM	8.9	8.6	7.3	7.0
NAKONSAWAN	6.3	6.3	5.9	6.2		NONHABURI	8.6	8.1	7.3	6.9
PHISANULOK	5.6	5.8	5.7	6.1						
KAMPHAENGPHET	5.6	5.8	5.6	5.7						
UTTARADIT	4.9	5.3	5.1	5.9						
UTHAITHANI	5.6	5.7	5.6	5.9						
SUKHOTHAI	5.9	5.9	5.8	6.0						
PHICHIT	5.8	5.9	5.7	6.0						
PETCHABUN	4.2	4.7	4.7	5.7						
SOUTHERN	6.6	6.5	6.0	6.4						
PHUKET	7.4	7.3	6.7	7.1						
SURAT THANI	7.8	7.2	6.3	6.3						
RANONG	7.3	7.2	6.3	6.6						
PHANGNGA	7.2	6.7	5.9	6.1						
KRABI	5.3	5.5	5.3	6.0						
CHUMPHON	6.7	6.6	5.8	6.1						
NAKHON SI THAMMARAT	8.0	7.3	6.4	6.4						
TRANG	6.0	6.1	5.7	6.4						
SONGKHLA	5.6	6.0	5.9	6.7						
SATUN	4.9	5.3	5.1	5.9						
YALA	5.3	5.7	5.5	6.3						
PATTANI	5.4	5.7	5.6	6.3						
NARATHIWAT	4.9	5.3	5.2	6.0						
PHATTALUNG	5.0	5.4	5.2	6.0						

Source: NESDB

## **CHAPTER 3**

# **TRAFFIC DEMAND FORECAST**



## CHAPTER 3

### TRAFFIC DEMAND FORECAST

To forecast the future OD tables and traffic demand on the national highways and the study routes of motorways, it is necessary first to establish the present trip pattern. Present inter-Changwat OD tables for the whole country were established based on the 1990 OD tables prepared in "The Toll Highway Development Study in the Kingdom of Thailand, JICA 1991", and by applying a trip generation model using highly-associated indicators of the 1993 socio-economic framework. Sub-zonal OD tables for sub-zones in the Changwats of the study routes were established based on the expanded trips of OD data collected during three traffic surveys. Combined generated and attracted trips were subject to a trip distribution iteration procedure of Fratar method to establish the OD tables. Assignment techniques were applied to allocate trips on the national highway network for the two cases of "with project" and "without project" to allocate future trips to the road networks and to estimate traffic volumes on both networks.

#### 3.1 TRAFFIC SURVEY

In this study, three traffic surveys were carried out in order to investigate the characteristics of the present trip pattern in the area influenced by the study routes and to forecast future traffic demand on them. The surveys aimed at trips which have their origin or destination within sub-zones of Changwats traversed by the study routes to estimate traffic volumes on the highways and motorways with higher accuracy.

##### 3.1.1 Mobilization

In the planning process of the traffic surveys and during the mobilization stage, the majority of tasks are focused on field operation planning to enable the survey work to progress efficiently and to insure a continuous flow of survey data. Survey forms are developed based on the forms used by DOH for recording data obtained by surveyors in the field; the forms are almost the same as those used in the Master Plan Study. The survey forms used are presented in Appendix 3.1-1. In addition, field reconnaissance was first done to locate the exact and appropriate sites which provide data collection requirements and safety considerations during the surveys. Collected information from this task includes:

- Station number
- Changwat and Amphoe jurisdiction
- Road width
- Number of lanes
- Location map
- Other remarks
- Road number
- Kilometer post
- Shoulder width
- Traffic volume (15 min.)
- Location photos

### 3.1.2 Methodology

Traffic surveys are carried out in this study according to the same procedures adopted in the Master Plan Study. The main survey is an OD roadside interview survey to collect trip data on a sub-zonal base for intra-Changwat trips. Traffic counting surveys are carried out at the same survey stations to estimate expansion factors required to expand the OD data on a daily base. In addition, traffic speed surveys are carried out on the same road sections to get basic data to estimate travel time on national highways.

#### 1. Traffic Counting Survey

##### a. Purpose

The purpose of this survey is to determine the distribution of vehicle categories in the traffic flow, so that expansion factors can be estimated to expand the OD data collected for twelve hours on a sampling base.

##### b. Procedure

The survey period at each station for this survey is twenty-four hours (06:00-06:00) on the same days and at the same as the OD survey, as presented in Table 3.1-1 and Figure 3.1-1. Manual counters are used to collect traffic composition data in both directions separately on a 15-minute base for the following vehicle categories:

- Tricycle (with engine)
- Passenger car and taxi
- Medium bus
- Pick-up
- 6-wheel truck (medium truck)
- Other vehicles (with engine)
- Motorcycle
- Light bus
- Heavy bus
- 4-wheel truck (light truck)
- 10-wheel truck (heavy truck)

TABLE 3.1-1 TRAFFIC SURVEY STATIONS

Station	Route	Km. Post	Changwat	Amphoe Boundary
<b>1. LAMPANG - DOI SAKET Route</b>				
N-1	11	9 + 400	Lampang	Lampang / Hang Chat
N-2	11	88 + 000	Chiang Mai	Saraphi / Chiang Mai
N-3	118	13 + 600	Chiang Mai	Chiang Mai / Doi Saket
N-4	107	25 + 000	Chiang Mai	Mae Taeng / Mae Rim
<b>2. BAN PONG - CHA AM Route</b>				
S-1	4	79 + 100	Ratchaburi	Ban Pong / Photharam
S-2	4	92 + 000	Ratchaburi	Photharam / Ratchaburi
S-3	4	114 + 320	Ratchaburi	Ratchaburi / Pak Tho
S-4	4	154 + 000	Phetchaburi	Khao Yoi / Phetchaburi
S-5	4	179 + 100	Phetchaburi	Ban Lat / Tha Yang

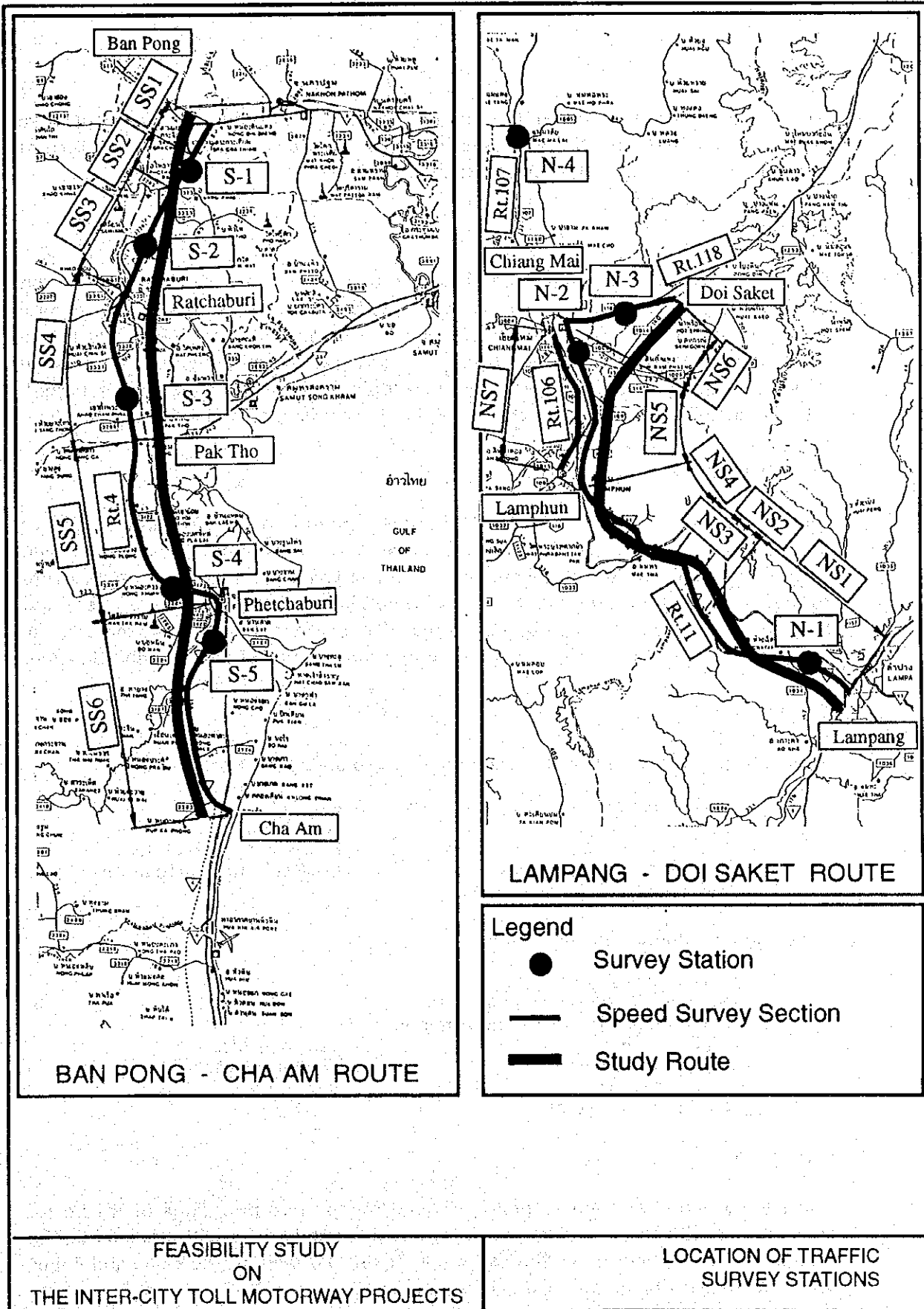


FIGURE 3.1-1 LOCATION OF TRAFFIC SURVEY STATIONS

## 2. OD Survey

### a. Purpose

The OD survey was conducted on national highways in order to collect trip data required to investigate the characteristics of the present movement pattern of passengers and commodities in the study area.

### b. Zoning

Changwats in the study area were divided into sub-zones which represent the unit of OD movements for future traffic forecast. Each sub-zone consists of several Amphoes and the survey stations are located on the national highways at the boundaries between sub-zones. OD data are collected on an administrative base in which the Amphoe and Changwat for each trip's origin and destination are recorded. The applied sub-zoning system for the study area is shown in Appendix 3.1-2.

### c. Survey Stations

The criteria in selecting the location of survey stations was set mainly to collect counting and OD data which represent the optimum movement of passenger and commodity vehicles for intra-Changwat trips. In total, nine survey stations were found to cover the requirements of the survey in which four survey stations are located in the area influenced by the northern motorway between Lampang and Doi Saket, and five stations for the southern motorway between Ban Pong and Cha Am.

### d. Survey Items

Drivers of the following vehicles were interviewed during the OD survey:

- Passenger car and taxi
- Medium bus
- Pick-up (passenger)
- 4-wheel truck (light truck)
- 10-wheel truck (heavy truck)
- Light bus
- Heavy bus
- Pick-up (commodity)
- 6-wheel truck (medium truck)

Collected data during the survey are:

- Vehicle category
- Origin (Changwat and Amphoe)
- Destination (Changwat and Amphoe)
- Load capacity
- Commodity volume
- Commodity type
- Number of assistants
- Seat capacity
- Number of passengers
- Trip purpose

### e. Procedure

The survey period at each station continued for the two directions of traffic for twelve hours (06:00-18:00) on weekdays avoiding only days with unusual traffic characteristics, during the month of October 1993. Portable traffic signs and cones were used for traffic control and safety purposes.



Sampling techniques were applied to get the target number of samples which was calculated for each survey station according to ADT (1992) using the following simplified formula which is diverted from the methodology of the Department of Transport in the United Kingdom and gives high sampling rates for low ADT and low rates for high ADT with a  $\pm 5\%$  accuracy rate.

$$\text{Target Sample Size} = \text{ADT} / (0.0003 \text{ ADT} + 1)$$

### 3. Traffic Speed Survey

#### a. Purpose

The purpose of this survey is to get basic speed measurements to estimate the travel time on each designated link of the national highways adjacent to the study motorways, and to be used as supplementary information to review the speed-flow relationship on main trunk highways directly related to the study routes.

#### b. Procedure

Survey locations were selected on different sections along all the national highways adjacent to the study motorways as shown in Figure 3.1-1. Seven sections are surveyed on the same days with other traffic surveys at various time periods. The floating car method, with a minimum of three runs for each traffic direction, was used to carry out this survey. The collected data are as follows:

- Road and section identification
- Day, date, direction and weather
- Start and finish time
- Time and distance for each run
- Traffic volume for 15 minutes  
(before and after the survey for each direction)

### 3.1.3 Survey Results

All the data collected in the field were first manually checked and scrutinized for errors, omissions and ambiguous classifications during the coding procedure. Next, data were subject to systematic checks which are applied through the data processing stage to verify the accuracy of coding and the consistency of trip data.

#### 1. Traffic Counting Survey

##### a. Traffic Volume Data

A summary of the collected traffic volume and composition data during the traffic surveys as well as the applied fluctuation factors are presented in Appendix 3.1-3. Data of the Traffic Engineering Division of DOH for permanent counting stations in the southern area and coverage stations in the northern area were used to obtain the daily, monthly or seasonal fluctuation factors to be applied to estimate average daily traffic volumes. Excluding motorcycles and tricycles, estimated average daily traffic volumes classified by six groups of vehicle categories are shown graphically in Figure 3.1-2 for the survey stations.

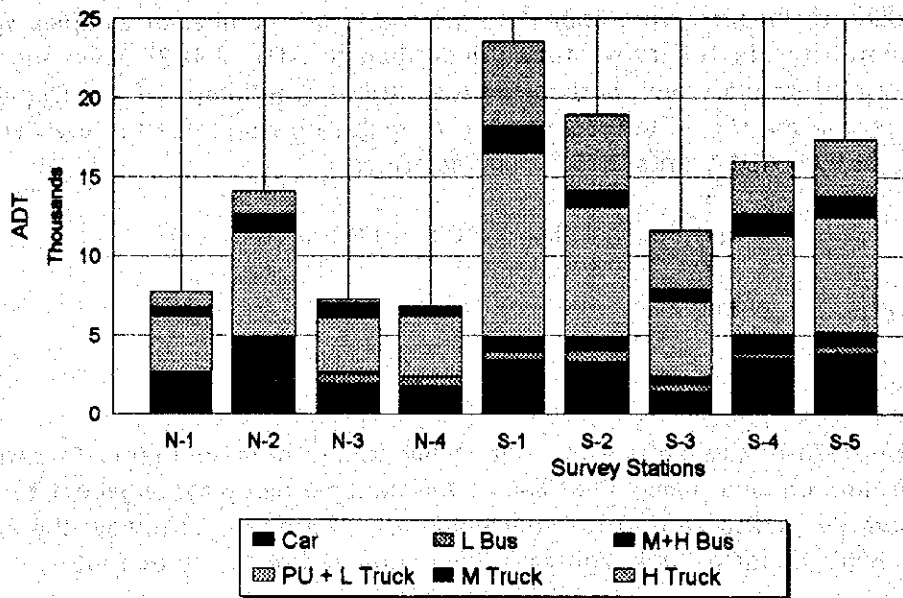


FIGURE 3.1-2 TRAFFIC COMPOSITION AT SURVEY STATIONS

b. Heavy Vehicle Share

The number of heavy vehicles running on the roads is an important factor to be considered, especially in the capacity analysis and in the pavement design and maintenance stages. The share of heavy vehicles, which are heavy buses and medium and heavy trucks, was determined separately based on the traffic count data for all the survey stations, and plotted as shown in Figure 3.1-3.

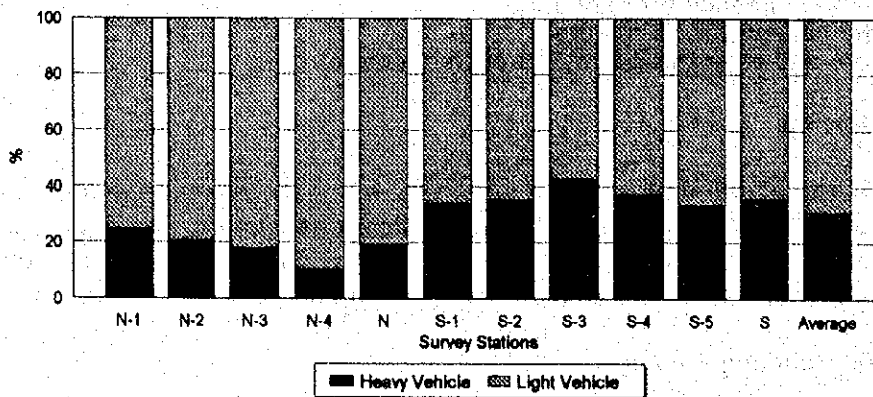


FIGURE 3.1-3 SHARE OF HEAVY VEHICLES

c. Nighttime Traffic

Appendix 3.1-4 includes the hourly variation in traffic volume for all survey stations, and the share of nighttime traffic is shown in Figure 3.1-4. On average, the share of nighttime traffic is about 28.8% of total traffic and stations in the northern area had, in total, a lower share of nighttime traffic with an average of 21.7% while the average for stations on Rt. 4 was 31.7%.

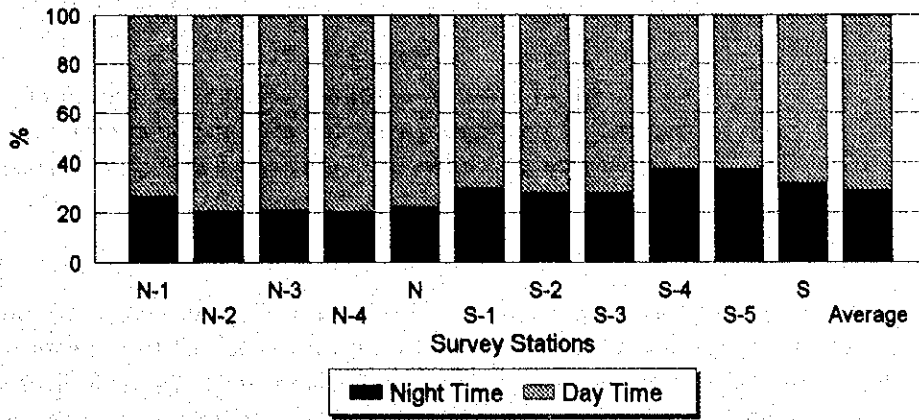


FIGURE 3.1-4 SHARE OF NIGHTTIME TRAFFIC

2. OD Survey

a. Collected Survey Data

The number of actual OD samples for vehicles interviewed at each survey station is presented in Appendix 3.1-5. The highest number was 3,623 samples collected for a daily traffic volume of 25,882 vehicles at station S-1, and the lowest of 2,930 samples collected for a daily traffic volume of 8,541 vehicles at station N-1. Figure 3.1-5 shows that the actually collected samples were, in total, higher than the estimated target samples

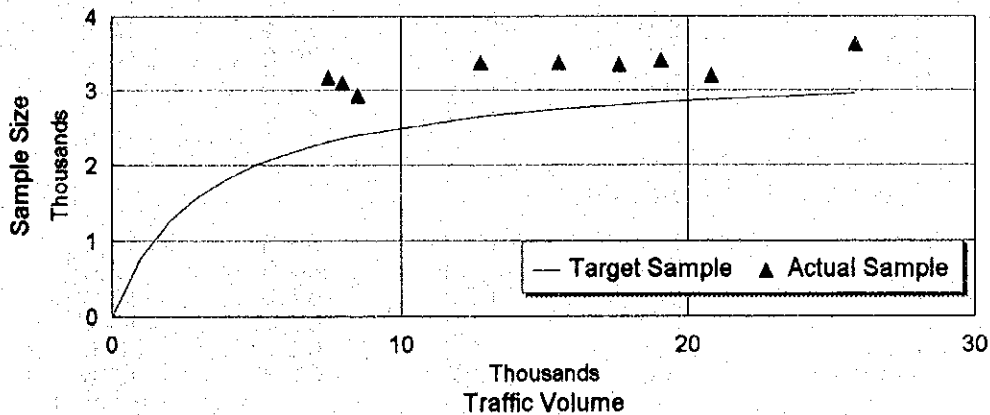


FIGURE 3.1-5 TARGET AND ACTUAL SAMPLE SIZE

b. Expansion Factors

Hourly expansion factors were applied to supplement the 12-hour OD data on 24-hour traffic volumes and other fluctuation factors were applied so that the bias in the collected data could be adjusted on the ADT basis of each road. Appendix 3.1-6 includes the estimated expansion factor for each survey road which were determined using the following formula:

$$a_{ijk} = T_{ijk} / t_{ijk}$$

Where,  $a_{ijk}$  : expansion factor of  $k$  category vehicles at station  $i$  in direction  $j$ ;  
 $T_{ijk}$  : number of  $k$  category vehicles at station  $i$  in direction  $j$ ; and  
 $t_{ijk}$  : sample size of  $k$  category vehicles at station  $i$  in direction  $j$ .

### c. Passenger-Vehicle Movement Characteristics

The following sections present the results of the OD survey, expanded for daily traffic volumes, to clarify the movement characteristics of the passenger vehicles as well as the total average, and to estimate parameters to be used in the economic evaluation procedure of the project routes. As the collected data of the medium bus category were very few, this category is included in the heavy bus category. The breakdown of these results on a directional base are presented in Appendix 3.1-7.

#### 1) Capacity

The average capacity for the four passenger-vehicle categories is 11.7 passengers at stations of the northern route, and 14.4 passengers at stations of the southern route. Table 3.1-2 gives the average capacity for the four categories at each survey station and the total average values.

TABLE 3.1-2 AVERAGE CAPACITY OF PASSENGER VEHICLES (person)

Station No.	Vehicle Category				Average
	Passenger Car	Light Bus	Heavy Bus	Pick-up Passenger	
<b>a. Lampang - Doi Saket Route</b>					
N-1	5.0	11.9	71.1	12.8	13.2
N-2	5.0	12.2	70.6	13.0	11.3
N-3	5.0	12.1	72.5	12.7	11.1
N-4	5.0	12.0	71.2	13.0	11.3
Average - N	5.0	12.1	71.1	12.9	11.7
<b>b. Ban Pong - Cha Am Route</b>					
S-1	5.0	12.3	56.3	11.9	13.3
S-2	5.0	11.3	64.0	12.0	13.6
S-3	5.1	13.0	67.2	11.9	14.6
S-4	5.0	14.5	59.1	13.4	16.0
S-5	5.1	14.9	63.7	13.9	14.9
Average - S	5.0	12.9	61.3	12.6	14.4
Total Average	5.0	12.6	62.9	12.7	13.4

#### 2) Occupancy

Occupancy data of passenger vehicles provide input to person-kilometers of travel and modal choice models which are normally used in comprehensive transportation studies, and these data are used here in the economic evaluation procedure of the project routes. The average values for each category of passenger vehicles are presented in Table 3.1-3 for all survey station.

**TABLE 3.1-3 AVERAGE NUMBER OF PASSENGERS** (person)

Station No.	Vehicle Category				Average
	Passenger Car	Light Bus	Heavy Bus	Pick-up Passenger	
<b>a. Lampang - Doi Saket Route</b>					
N-1	2.5	6.8	54.9	2.8	5.7
N-2	2.0	4.4	40.8	2.7	3.6
N-3	2.3	6.4	61.8	2.7	4.1
N-4	2.3	8.1	65.4	2.6	4.0
Average - N	2.2	6.9	51.5	2.7	4.2
<b>b. Ban Pong - Cha Am Route</b>					
S-1	2.1	3.2	27.5	2.9	4.5
S-2	2.1	4.6	38.0	2.5	5.1
S-3	2.4	6.6	34.3	2.8	5.4
S-4	2.4	3.7	30.8	2.7	6.1
S-5	2.4	5.2	31.6	3.1	5.3
Average - S	2.3	4.7	32.0	2.8	5.2
Total Average	2.2	5.5	35.2	2.8	4.9

**3) Trip Purpose**

Trip purpose is classified into four types: to/from work, private trip, tour and others. As only drivers of passenger cars and pick-ups were interviewed during the traffic survey regarding their trip purpose, Table 3.1-4 presents the average percentage for the trip purpose of passengers at each survey station.

**TABLE 3.1-4 TRIP PURPOSE OF PASSENGER VEHICLES** (%)

Station No.	Passenger Car				Pick-up Passenger			
	Work	Private	Tour	Other	Work	Private	Tour	Other
<b>a. Lampang - Doi Saket Route</b>								
N-1	34.3	48.5	15.0	2.1	47.6	42.5	8.1	1.8
N-2	49.0	40.5	9.0	1.4	53.2	37.8	5.8	3.2
N-3	48.5	43.6	5.5	2.5	48.5	40.4	9.0	2.1
N-4	53.2	38.0	7.7	1.0	50.7	44.9	3.7	0.7
Average - N	46.6	42.8	8.7	1.9	50.1	41.6	6.4	1.9
<b>b. Ban Pong - Cha Am Route</b>								
S-1	54.6	42.2	3.2	0.0	59.7	38.0	2.0	0.3
S-2	51.9	45.3	2.7	0.0	54.5	43.8	1.7	0.0
S-3	51.5	42.2	6.0	0.3	54.5	42.3	3.2	0.0
S-4	50.7	38.3	7.2	3.8	52.0	42.0	3.9	2.1
S-5	41.3	45.9	8.0	4.8	47.2	44.0	5.7	3.1
Average - S	48.4	43.0	6.1	2.4	51.9	43.0	3.7	1.4
Total Average	47.5	42.9	7.4	2.1	50.9	42.2	5.2	1.7

**d. Commodity-Vehicle Movement Characteristics**

The average values of expanded daily traffic data related to the movement and loading characteristics of commodity vehicles are presented in the following sections separately for each of the survey stations, while Appendix 3.1-8 gives these results for each direction of traffic separately.

## 1) Capacity

The average capacity in tons for the four categories of commodity vehicles interviewed during the OD survey is presented in Table 3.1-5 at all survey stations. Capacity values did not differ too much in either area, with a total average capacity of 7.26 tons in the northern area and 7.84 tons in the southern area.

## 2) Payload

The payload is estimated approximately according to the proportion of loaded volume to total capacity in tons. Table 3.1-6 gives the estimated values of the average payload for each of the four categories of commodity vehicles, excluding empty vehicles, at each survey station. The average payload per commodity vehicle was 4.02 tons, which gives a loading rate of about 52% in average.

TABLE 3.1-5 AVERAGE CAPACITY OF COMMODITY VEHICLES (ton)

Station No.	Vehicle Category				Average
	Pick-up	L. Truck	M. Truck	H. Truck	
<b>a. Lampang - Doi Saket Route</b>					
N-1	1.49	3.00	3.62	11.59	8.98
N-2	1.50	3.06	7.50	11.29	7.51
N-3	1.50	3.00	7.74	11.04	6.39
N-4	1.50	3.33	7.64	10.79	5.27
Average - N	1.50	3.12	7.62	11.34	7.26
<b>b. Ban Pong - Cha Am Route</b>					
S-1	1.23	3.51	6.29	10.56	6.68
S-2	1.23	3.57	6.24	10.77	7.90
S-3	1.17	3.26	6.02	10.04	7.64
S-4	1.48	3.10	7.60	12.83	8.74
S-5	1.50	3.31	7.80	13.24	9.05
Average - S	1.31	3.41	6.86	11.34	7.84
Total Average	1.35	3.36	7.11	11.34	7.74

TABLE 3.1-6 AVERAGE PAYLOAD OF COMMODITY VEHICLES (ton)

Station No.	Vehicle Category				Average
	Pick-up	L. Truck	M. Truck	H. Truck	
<b>a. Lampang - Doi Saket Route</b>					
N-1	0.81	1.77	3.52	6.86	5.02
N-2	0.88	0.33	3.36	5.65	3.60
N-3	0.86	0.87	3.22	4.41	2.61
N-4	0.93	1.46	3.33	4.65	2.38
Average - N	0.88	0.98	3.34	5.88	3.52
<b>b. Ban Pong - Cha Am Route</b>					
S-1	0.61	1.69	2.96	4.83	3.09
S-2	0.62	1.82	2.91	4.66	3.48
S-3	0.62	1.41	2.51	4.41	3.36
S-4	0.82	1.26	3.85	8.75	5.59
S-5	0.89	1.38	3.89	9.22	5.92
Average - S	0.70	1.58	3.29	6.10	4.13
Total Average	0.73	1.47	3.31	6.07	4.02

### 3) Empty vehicles

Table 3.1-7 gives the percentage of empty vehicles for the four categories of commodity vehicles and the average for the total of two directions.

### 4) Average Number of Assistants

Table 3.1-8 gives the average number of assistants for the four categories of commodity vehicles with an average of 0.61 person in the northern area and 0.50 person in the southern area.

TABLE 3.1-7 PERCENTAGE OF EMPTY COMMODITY VEHICLES ( % )

Station No.	Vehicle Category				Average
	Pick-up	L. Truck	M. Truck	H. Truck	
<b>a. Lampang - Doi Saket Route</b>					
N-1	36.1	32.7	43.2	37.8	39.0
N-2	22.8	88.6	44.0	44.6	41.8
N-3	29.9	63.5	53.2	56.3	50.9
N-4	18.9	61.1	48.0	51.7	41.3
Average - N	24.8	67.0	47.2	43.8	43.0
<b>b. Ban Pong - Cha Am Route</b>					
S-1	27.6	28.3	37.5	42.1	36.0
S-2	32.7	36.4	41.5	48.0	43.5
S-3	24.8	40.8	44.1	45.8	41.8
S-4	22.9	46.4	39.5	26.4	29.6
S-5	24.3	41.4	39.9	26.5	29.3
Average - S	26.8	34.6	39.9	38.9	36.1
Total Average	26.5	40.8	42.3	39.5	37.4

TABLE 3.1-8 AVERAGE NUMBER OF ASSISTANTS (person)

Station No.	Vehicle Category				Average
	Pick-up	L. Truck	M. Truck	H. Truck	
<b>a. Lampang - Doi Saket Route</b>					
N-1	0.83	0.85	0.79	0.64	0.71
N-2	0.74	0.55	0.59	0.57	0.62
N-3	0.49	0.79	0.53	0.41	0.54
N-4	0.50	0.79	0.53	0.53	0.57
Average - N	0.65	0.73	0.60	0.58	0.61
<b>b. Ban Pong - Cha Am Route</b>					
S-1	0.45	0.58	0.50	0.36	0.43
S-2	0.61	0.45	0.59	0.35	0.44
S-3	0.72	0.50	0.58	0.33	0.44
S-4	0.63	0.83	0.85	0.69	0.72
S-5	0.43	0.56	0.60	0.54	0.53
Average - S	0.54	0.58	0.62	0.44	0.50
Total Average	0.56	0.61	0.62	0.45	0.52

#### 4) Commodity Distribution

The total number of 23 commodity types, according to the classification of the Land Transport Department (LTD) is grouped into four different categories: 1) agricultural products, 2) construction materials, 3) manufacturing products, and 4) other products. Figure 3.1-6 presents the percentage of estimated commodity share for each group at the survey stations for the total of two directions of traffic.

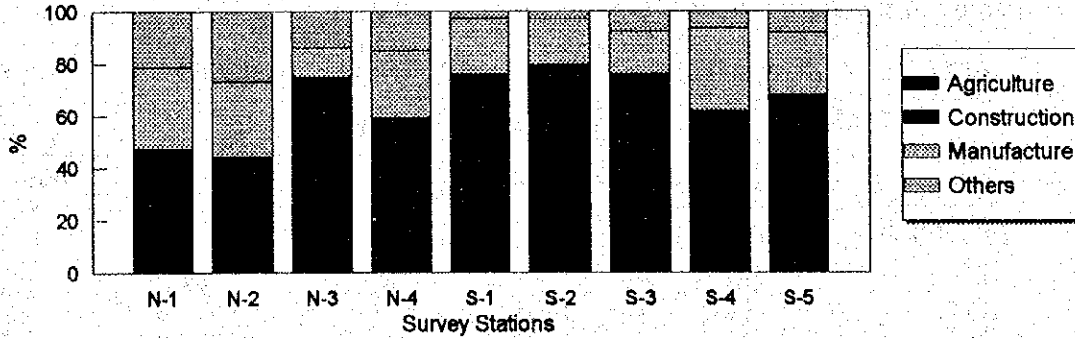


FIGURE 3.1-6 COMMODITY DISTRIBUTION

#### 3. Traffic Speed Survey

Traffic speed surveys were carried out at seven locations on the national highways in the northern area and at six locations in the southern area, selected based on the location of the OD and traffic counting surveys. Location and average results of the speed survey are presented in Appendix 3.1-9, while Figure 3.1-7 shows the general trend of speed in accordance with the hourly traffic volume. It can be noticed that speed measurements are nearly equal in general for the surveyed sections, either for 2-lane or 4-lane highways, except for Rt. 106 which runs mostly in populated surroundings. Speed on the mountainous sections also have the same high values due to the existence of a climbing lane for slow traffic.

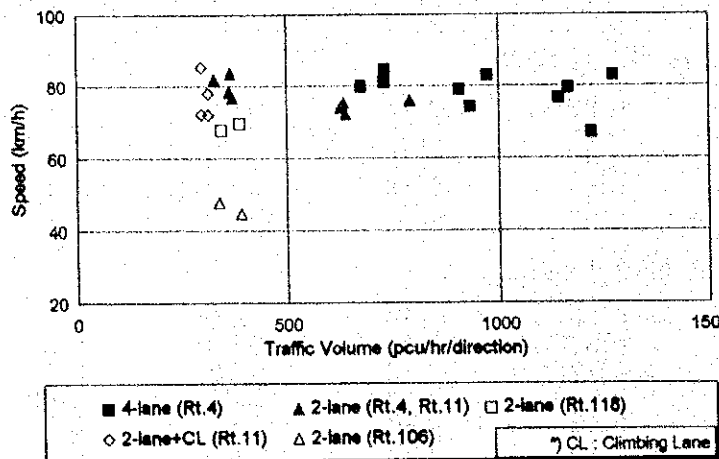


FIGURE 3.1-7 SPEED SURVEY RESULTS



### 3.2 PRESENT AND FUTURE OD TABLES

#### 3.2.1 Methodology for Establishment of Present OD Tables

Present OD table for each vehicle category is basically composed of inter-Changwat trips for the whole country and sub-zonal trips for Changwats traversed by the study routes as clarified in the zoning system in Appendix 3.1-2. Following sections present the methodology applied to establish the different components of the present OD table.

##### 1. Inter-Changwat Trips

As the OD survey was planned to collect OD samples on sub-zonal base in the Changwats traversed by the study routes, the trip generation and distribution pattern of the 1990 OD table established in the Master Plan Study was utilized as the basis of the 1993 OD table. The developed trip generation model was applied to estimate the trip generation of 1993 based on the 1990 trip generation and by utilizing the values of sectoral GPP of the 1993 socio-economic framework. For the trip distribution procedure, Fratar method was applied in accordance with the 1990 trip distribution pattern. Due to improvements in the highway network between 1990 and 1993, an induced trip model was applied to estimate produced trips which were added to the 1993 inter-Changwat trips. The structure of the trip generation model and induced trip model is presented in following sections while Figure 3.2-1 shows the flow chart of the methodology used in this stage.

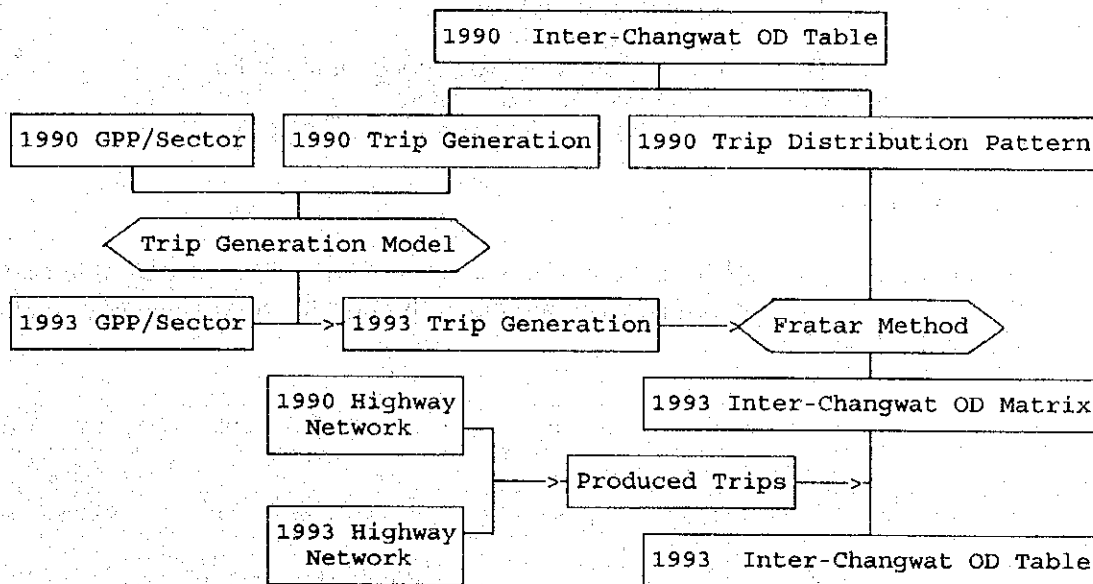


FIGURE 3.2-1 ESTABLISHMENT OF INTER-CHANGWAT OD TABLES - 1993

##### 2. Sub-zonal Trips

The Changwats traversed by the study routes were divided into sub-zones and traffic survey was carried out at boundaries between these sub-zones. The overall procedure is presented in the flow chart of Figure 3.2-2.

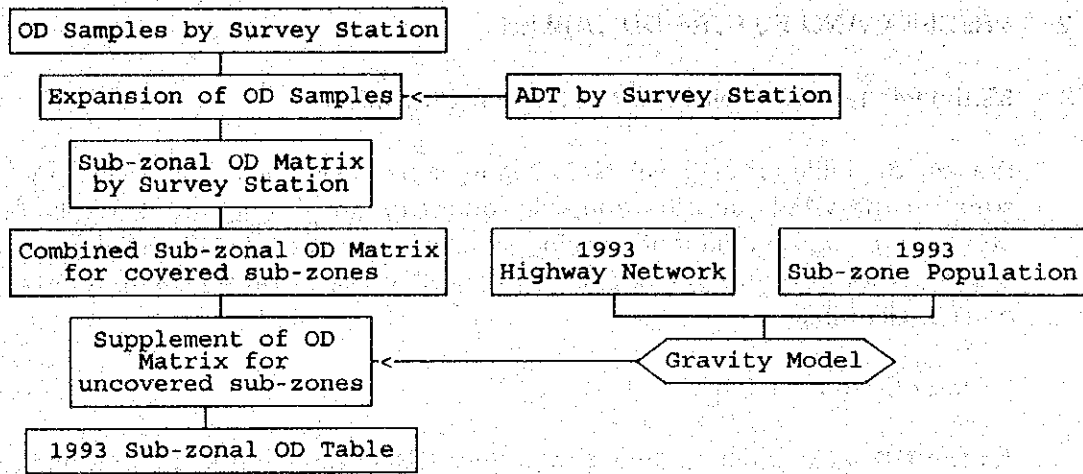


FIGURE 3.2-2 ESTABLISHMENT OF SUB-ZONAL OD TABLES - 1993

Collected OD samples at survey stations were expanded, based on the counting survey results and estimated ADT, to produce OD table for known OD pairs of each survey station. OD tables of all stations were combined and supplemented by trips estimated through a gravity model for unknown OD pairs of uncovered sub-zones. The gravity model, which is based on the sub-zonal population and highway network, has the following form:

$$T_{ij} = a (P_i * P_j)^b / D_{ij}^c$$

where,

- $T_{ij}$  : number of trips from sub-zone  $i$  to sub-zone  $j$
- $P_i$  : population of sub-zone  $i$
- $P_j$  : population of sub-zone  $j$
- $D_{ij}$  : distance between sub-zones  $i$  and  $j$  in km
- $a, b$  &  $c$  : parameters with the values:  
 $a = 568$      $b = 0.836$      $c = 2.50$

### 3. Zonal Trips

As shown in Figure 3.2-3 of the establishment of the combined OD table of zonal trips, it is composed of components produced through the inter-Changwat and sub-zonal OD tables.

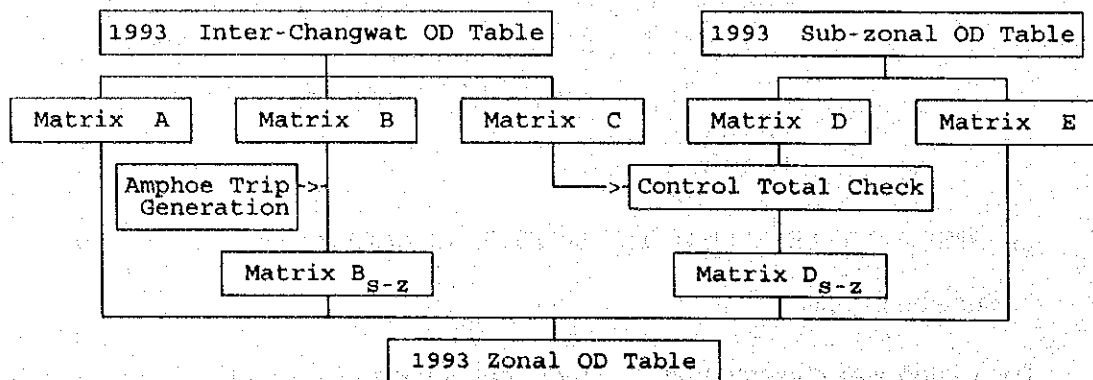


FIGURE 3.2-3 ESTABLISHMENT OF ZONAL OD TABLES - 1993

Component matrices of the combined zonal OD table are clarified in Figure 3.2-4 and can be defined as follows:

Inter-Changwat OD Table is divided to:

- Matrix A: trips between Changwats other than those of a study route
- Matrix B: trips between Changwats of a study route and other Changwats
- Matrix C: trips between Changwats of a study route

Sub-zonal OD Table is divided to:

- Matrix D: trips between sub-zones in two Changwats of a study route (inter-Changwat inter-subzone trips)
- Matrix E: trips between sub-zones in one Changwat of a study route (intra-Changwat inter-subzone trips)

Zonal OD Table is combined of:

- Matrix A
- Matrix B<sub>s-z</sub>: trips between sub-zones in Changwats of a study route and other Changwats
- Matrix D<sub>s-z</sub>: calibrated trips between sub-zones in two Changwats of a study route
- Matrix E

Origin \ Destination			Changwat of study routes*)				Changwat other than that of study routes
			Changwat		Changwat		
			Sub-zone	Sub-zone	Sub-zone	Sub-zone	
Changwat of study routes*)	Changwat	Sub-zone	<b>Matrix E</b>	<b>Matrix D<sub>s-z</sub></b>	<b>Matrix B<sub>s-z</sub></b>		
		Sub-zone					
	Changwat	Sub-zone	<b>Matrix D<sub>s-z</sub></b>	<b>Matrix E</b>			
		Sub-zone					
Changwat other than that of study routes			<b>Matrix B<sub>s-z</sub></b>		<b>Matrix A</b>		

\*) ; Chiang Mai , Lamphun , Lampang , Ratchaburi & Phetchaburi

FIGURE 3.2-4 COMPONENTS OF COMBINED ZONAL OD TABLE

### 3.2.2 Methodology for Establishment of Future OD Tables

#### 1. Target Years

To predict future OD tables and prepare future road networks for traffic assignment, target years were determined based on the tentative implementation plan presented in Figure 3.2-5 for the two study routes taking into account the different required stages of implementation.

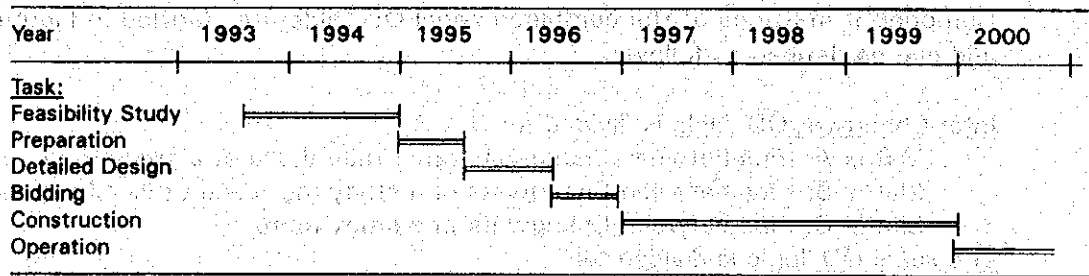


FIGURE 3.2-5 TENTATIVE IMPLEMENTATION PLAN

Based on the above schedule for implementing the two study routes and assuming a life-span of 20 years for the project routes, the target years were determined to be as follows:

Operating Year: 2000  
 Intermediate Year: 2010  
 Life-span Year: 2020

2. Procedure

Figure 3.2-6 presents the flow chart of the methodology applied to establish the future OD table for each target year. Target year parameters of sectoral GPP in the

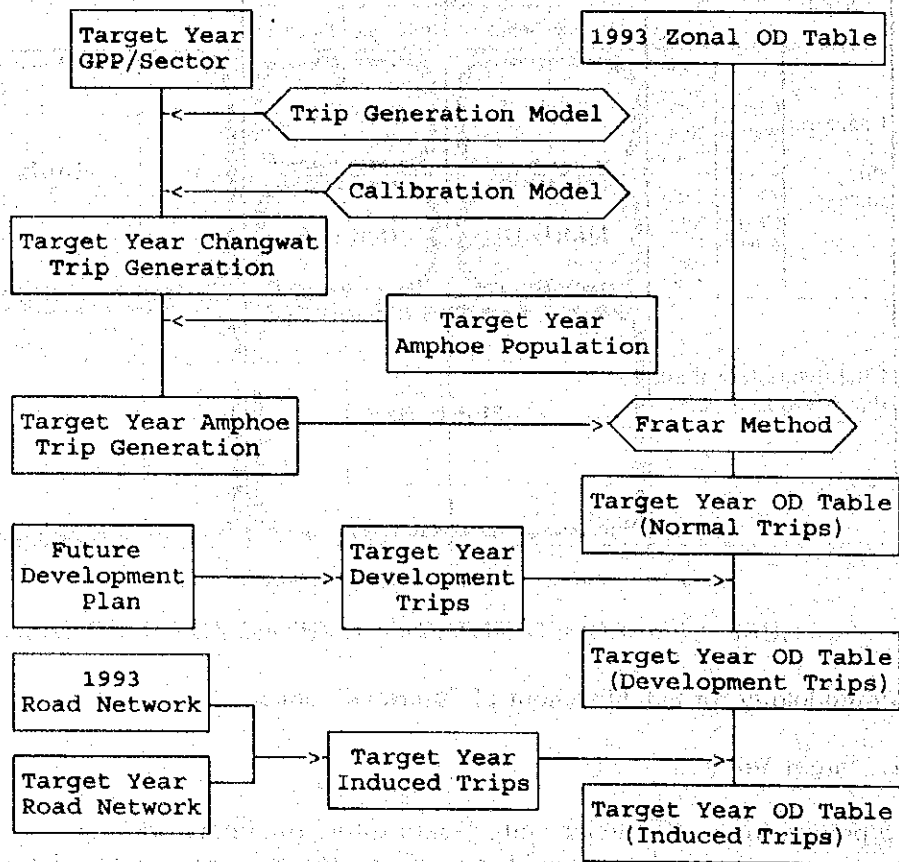


FIGURE 3.2-6 ESTABLISHMENT OF FUTURE OD TABLES

future socio-economic framework were applied to the trip generation model to estimate future inter-Changwat trip generation. For Changwats traversed by the study routes, future Amphoe population was used to breakdown Changwat trips into sub-zonal trips.

Trips predicted for each vehicle category through the trip generation model were calibrated using the principal component method for the total of passenger vehicles and commodity vehicles. Fratar method was applied for the trip distribution procedure to synthesize the future trip-interchange magnitudes and to overcome imbalances in the trip distribution so that interchanges ultimately balance by direction. Added to the basic OD table are the development trips generated by future development plans and induced trips due to improvements of the highway network, either widening or construction of new roads, and construction of motorways. Induced trips due to the construction of the study routes are added only in the case of "with project".

### 3.2.3 Trip Generation Model

#### 1. Model Structure

The trip generation model developed in the master plan study is used in this study to estimate the present and future trip generation. Parameters for different vehicle categories were reestimated based on the data of GPP by sector which are the highly associated independent variables for generated inter-changwat trips. The used values of GPP by sector as estimated in the socio-economic framework of the study are presented in Appendix 3.2-1. As the changwats of BMR have extremely high economic parameters comparing with other changwats, they were treated independently in the model when applied for other changwats. In this process, a unit value was applied for each parameter of the BMR changwats which means dummy BMR. The model has the form:

$$T_k = a * GPP_1 + b * GPP_2 + c * GPP_T + d * (BMR \text{ dummy}) + e$$

where,  $T_k$  : number of trips for vehicle category  $k$   
 $GPP_{1,2 \& T}$  : GPP of sectors 1 (agricultural), 2 (industrial) and total GPP in million Baht  
 $a, b, c, d \& e$  : parameters which have the following values for each vehicle category:

Vehicle Category	$a$	$b$	$c$	$d$	$e$	Multiple Correlation Coefficient $R^2$
PC	0.0	0.2621	0.0	2,486	842	0.952
LB	0.0	0.0	0.0163	0	183	0.826
HB	0.0477	0.0830	0.0	0	40	0.955
PP	0.3393	0.1015	0.0	908	401	0.815
LT	0.2104	0.0618	0.0	1,110	521	0.797
MT	0.0764	0.0683	0.0	1,834	241	0.930
HT	0.3412	0.1050	0.0	3,856	-108	0.748

#### 2. Model Calibration

The principal component method was applied for the purpose of calibrating the total of passenger and commodity vehicle trips generated through the trip generation

model for each vehicle category. In this method, which avoids producing negative coefficients as in the direct application of multiple regression analysis, generated trips are applied as control totals for the two groups of passenger and commodity vehicles. The formula is also based on the same highly associated parameters of GPP by sector as follows:

$$Z_i = \alpha_1 * GPP_{1i} + \alpha_2 * GPP_{2i} + \alpha_3 * GPP_{3i}$$

where,  $Z_i$  : first principal component score for zone  $i$   
 $GPP_{1,2 \& 3}$  : GPP of sectors 1 (agricultural), 2 (industrial) and 3 (services) in million Baht  
 $\alpha_{1,2 \& 3}$  : parameters with the values;  
 $\alpha_1 = 0.3911$      $\alpha_2 = 0.6474$      $\alpha_3 = 0.6541$   
 Contribution ratio of first principal component = 72.5%

The first principal component score  $Z_i$  is applied in the following formula in order to estimate the number of generated trips per vehicle group for each zone:

$$C_i = a * Z_i^b$$

where,  $C_i$  : number of generated trips per vehicle group  
 $a \& b$  : parameters with the values:  
 Passenger vehicles:     $a = 0.6384$      $b = 0.9970$   
 Commodity vehicles:     $a = 0.2198$      $b = 1.0623$

### 3.2.4 Methodology for Estimation of Induced Trips

Induced trips to be added to future OD tables in this study are those trips which are produced in the case of "with project" due to the implementation of each one of the two study routes. Induced trips were estimated according to the methodology shown in Figure 3.2-7.

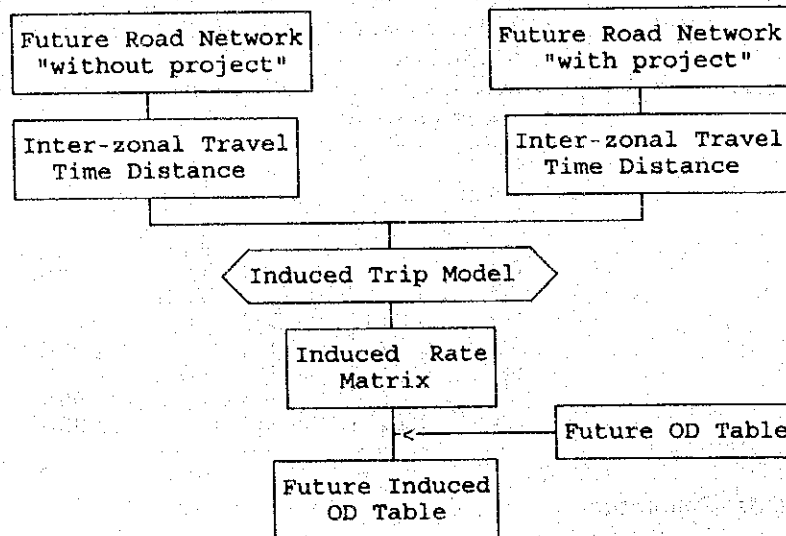


FIGURE 3.2-7 ESTABLISHMENT OF INDUCED OD TABLES