

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
POLLUTION CONTROL DEPARTMENT
THE GOVERNMENT OF THE KINGDOM OF THAILAND



FINAL REPORT
VOL.3
SUPPORTING REPORT

FEBRUARY 2003

THE **ACID** DEPOSITION CONTROL STRATEGY
IN THE KINGDOM OF THAILAND

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The exchange rates applied in this Study are:

US\$ 1.00 = Japanese Yen 120.00

Baht 1.00 = Japanese Yen 2.85

(as of February 2003)

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1. Acid Deposition and Air Quality Monitoring System

1.1 Brief Description of Monitoring Activity

1.1.1 Air Quality Monitoring Network and the Collected Data

PCD has been conducting the Air Quality Monitoring since 1992, and now 52 monitoring stations are operated in the whole country as shown in Table 1.1.1.1. And Table 1.1.1.2 and Figure 1.1.1.1 show detailed location of the monitoring station.

Table 1.1.1.1 Location of Air Monitoring Station

No.	Site Area	Site Name	Station No.
1	North Area	Chiang Mai	35, 36
2		Lampang	37, 38, 39, 40
3		Nakorn Sawan	41
4	East-north Area	Kon Kaen	46
5		Nakorn Rachasima	47
6	East Area	Chomburi	28, 32, 33, 34
7		Rayong	29, 30, 31
8	Central Area	Bangkok	1, 2, 3, 5, 7, 9, 10, 11, 12, 15, 48, 49, 50, 51, 52, 53, 54
9		Pathum Thani	20
10		Nonthaburi	13, 22
11		Samut Prakan	8, 16, 17, 18, 19
12		Sara Buri	24, 25
13		Ayutaya	21
14		Nakorn Patum	6, 23
15		Rachaburi	26
16		Samut Sakorn	14, 27
17	South Area	Surat Thani	42
18		Phuket	43
19		Songkhla	44

Underlined station was not available in 2000.

Source: PCD, modified by the Study Team



Table 1.1.1.2(1) Detailed Location of Monitoring Station

Area	North Area							East-North Area	
Province	Chiang Mai		Lampang				Nakorn Sawan	Khon Kaen	Nakorn Rachasima
No.	35T	36T	37A	38A	39T	40T	41T	46T	47T
Site Name	"Changmai 35T"	"Changmai 36T"	Lampang 1	Lampang 2	"Ta See 39"	"Mae Moh 40"	"Nakhonsawan 41T"	"Khonkaen 46T"	"Nakhonratchasri ma 47T"
Location	Chiang Mai government service center, Chiang Mai Prov.	Uparat collect, Chiang Mai Prov.	Lampang Provincial Administration Office Lampang Prov.	Sob Pad Health Center, Mae Moh Lampang Prov.	Ta see Health Center, Mae Moh, Lampang Prov.	Mae Moh-The Provincial Waterwork Authority, Mae Moh, Lampang Prov.	Nakhon Sawan Technical Collect Nakhon Sawan Prov.	Khon Kaen Permanent Secretary House, Khon Kaen Prov.	The Residential of Commanding General 21th, Nakhonrachasima Prov.

Area	East Area						
Province	Chomburi				Rayong		
No.	28	32T	33T	34T	29T	30T	31T
Site Name	Pattaya	"Laem Chabang Chonburi 32T"	"Siracha Chonburi 33T"	"General Educationion Chonburi 34T"	"MaptaPut 29T"	"Rayong 30T"	"Rayong 31T"
Location		Laem Chabang District Administration office, Chonburi Prov.	The Siracha Juvenile Center Siracha, Chonburi Prov.	Chonburi General Education Office, Chonburi Prov.	Maptapud Health Center, Rayong Prov.	Rayong Telephone services center Rayong Prov.	Rayong Field Crops Research Center, Mab tapud, Rayong Prov.

Area	Central Area								
Province	Bangkok								
No.	01T	02T	03T	05T	07T	09T	10T	11T	12T
Site Name	"OEPP 01T"	"Ban Somdet jaopraya 02T"	"Ratburana 03T"	"Meteorological Dept. 05T"	"Junkasame 07T"	"Ramkhamhaeng 09T"	"National Housing Authority 10T"	"Huai Khwang 11T"	"None-tree Vitaya 12T"
Location	OEPP Rama6 rd. BKK	Rachapat Somdat Jao praya Inst. Itsarapab rd., BKK	Ratburana Post Office Phachautid rd., BKK	Meteorological Department Sukuvit rd., BKK	Rachapat Junkasame institute Rachadapisek rd., BKK	Ramkhamhaeng University Ramkhaeng rd., BKK	National Hosing Authority, Sukhsphiban1 rd., BKK	Huai Khwang Hosing Authority Pacha Songkhao re., Huai Khwang, BKK	None tree Vitaya school Nange lin gee rd., BKK

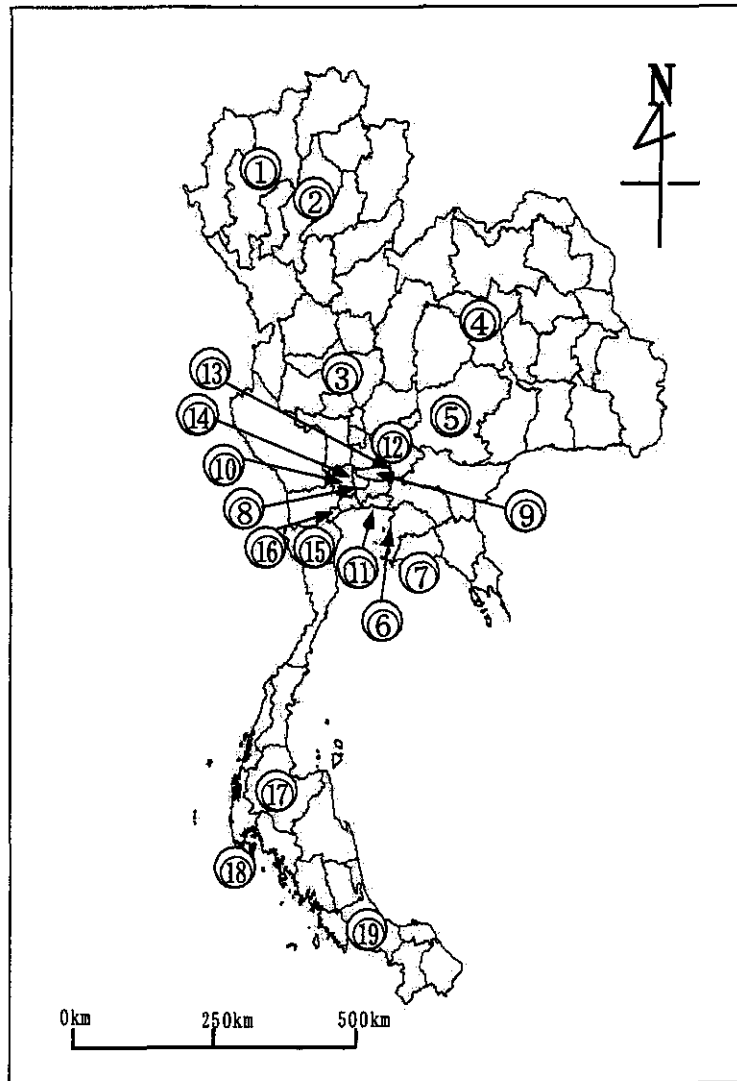
Table 1.1.1.2(2) Detailed Location of Monitoring Station

Area	Central Area									
Province					Pathum Thani	Nonthaburi			Samut Prakan	
No.	15T	52T	53T	54T	20T	13T	22T	08T	16T	
Site Name	"Singharatpitayakom 15T"	"Thonburi Substation, Intrapitak Rd. 52T"	"Traffic Police Residence 53T"	"Dindang Housing Authority 54T"	"Rangsit 20T"	"(EGAT) Dept. of Energy Affairs 13T"	"Sukothai Univesity 22T"	"Prabadang Rehabilitation 08T"	"(EGAT) South Bangkok 16T "	
Location	Singharatpitayakom School Eiggachi rd., Bangkoontein, BKK	Metropolitan Electriccity Authority, Thonburi Substation, Intrapitak rd., BKK	Traffic Police Residence, Chock Chai 4 Lat Phrao rd., Bang Kapi, BKK	Din Dang Housing Authority, Din Dang rd., Din Dang, BKK	Bangkok University Rangsit, Pathum Thani Prov.	Training Div., Dept. of Energy Affairs Bang Kruai, Nonthaburi Prov.	Sukothai Thamma Thiraj University Pakked, Nonthaburi Prov.	Prabadang Rehabilitation for the Disabled, Pathong rd., Samput Prakan Proy.	South Bangkok Power Plant Samut Prakan Prov.	

Area	Central Area							
Province				Sara Buri		Ayutaya	Nakorn Patum	
No.	17T	18T	19T	24T	25T	21T	06T	23T
Site Name	"Prabadang Mineral Resources 17T"	"Samutprakan 18T"	"Bangplee Housing Authority 19T"	"Saraburi 24T"	"Kao Noy Saraburi 25T"	Ayuttaya	"Mahidol salaya 06T"	"Sanamchan Nakhonpathom 23T"
Location	Dept. of Mineral Resources, Prabadang, Samut Prakan Prov.	Samut Prakan Provincial Administration Samut Prakan Prov.	Bangplee Housing Authority Bangplee, Samut Prakan Prov.	Napralan school, (Piboonsongkok) Saraburi Prov.	Keo Noy Police Fire Station Saraburi Prov.	Phra Nakhon Si Ayutaya collect Phra Nakhon Si Ayutaya Prov.	Mahidol University, Saraya Nakhon Pathom Prov.	Silpakhon University, Sanamchan Palace Campus, Nakhon Pathom Prov.

Area	Central Area			South Area		
Province	Rachaburi	Samut Sakorn		Surat Thani	Phuket	Songkhla
No.	26T	14T	27T	42T	43T	44T
Site Name	"Ratchaburi Engineer Department 26T"	"Thonburi Highway Dist. 14T"	"Samutsakhon 27T"	"Suratthani 42T"	Phuket	"Hatyai_ New 44T"
Location	Ratchaburi Engineer Dept. Royol Thai Army, Rachaburi prov.	Thonburi Highway Dist. Ka toom ban, Samut Sakhon Prov.	Samut Sakhon Provincial Administration Office, Samut Sakhon Prov.	Suratthani District Administration Office, Suratthani Prov.	Phuket Health Service Center, Phuket Prov.	Hatyai, Songkhla Prov.

Source: PCD, modified by the Study Team



Source: PCD, modified by the Study Team

Figure 1.1.1.1 Location of Air Quality Monitoring Station

In this network, SO₂, NO₂, NO, NO_x, CO, PM₁₀, O₃, HC and meteorological parameters have been measured. All the parameters are automatically measured, the data is also automatically transferred to the network center in the PCD. Technical methods for acid deposition monitoring parameters are shown in Table 1.1.1.3.

Table 1.1.1.3 Technical Methods for Acid Deposition Monitoring Parameters

Parameter	Method	Frequency	Note
SO ₂	UV-Fluorescence	Continually Measure	Same as Air Quality Monitoring Network
NO ₂	Calculation		
NO	Chemiluminescence		
O ₃	UV-Absorption		
PM ₁₀	Beta-Gauge		

Source: PCD



Data validation is managed by Air Quality Monitoring Sub Division (hereinafter referred to as AQMSD)-I according to the guideline prepared by PCD. Major contents of this guideline consists of on-line system checking, calibration report checking and maintenance record of equipment checking.

1.1.2 Overview of Monitoring Network for Acid Deposition in Thailand

The EANET network in Thailand started by four monitoring sites, and Chiang Mai site was added in October 2000. Three monitoring sites, located in Bangkok, Samutprakan and Kanchanaburi, are set at the same points of the air monitoring station. Some authorities including PCD take charge of sampling and analyzing work as shown in Table 1.1.2.1. However, the PCD has responsibility for management of the EANET in Thailand. And detailed descriptions of the monitoring contents are shown in Table 1.1.2.2.

Table 1.1.2.1 Brief Description of the Monitoring sites in the EANET

Monitoring Site	Bangkok	Samutprakam	Patumthani	Kanchanaburi	Chiang Mai
Site Name	OEPP ⁽¹⁾	TMD	ERTC	Khao Laem Dam	Mae-Hia Campus, Chiang Mai University
Station ID	01E	02E	03E	04E	05E
Area	Center	Center	Center	West	North
Site Classification	Urban	Urban	Rural	Remote	Rural
Monitoring Parameter	Rain, Air	Rain, Air	Rain	Rain, Air, Soil & Vegetation, Inland Aquatic Environments	Rain
Location	13° 46' N 100° 32' E	13° 40' N 100° 34' E	14° 02' N 100° 46' E	14° 46' N 98° 35' E	18° 50' N 98° 75' E
Altitude	2 m	2 m	2 m	170 m	300 m
Height of Sampling Funnel from the Ground Level	16 m	60 m	1.5 m	1.5 m	1.5 m
Responsibility (Sampling Work)	PCD	TMD	ERTC	EGAT/PCD ⁽²⁾ DOA RFD	Chiang Mai Univ.
Responsibility (Laboratory Work)	PCD	TMD ⁽³⁾	ERTC	PCD ⁽⁴⁾ King Mongkut Univ.	King Mongkut Univ./PCD

(1) Bangkok site was moved to the top of the PCD Building.

(2) EGAT/PCD for Dry/Wet Deposition/Inland Aquatic, DOA for Soil, RFD for Vegetation.

(3) TMD manages King Mongkut University's students to analyze by IC.

(4) PCD for Dry/Wet Deposition and Inland Aquatic, King Mongkut Univ. for Soil and Vegetation.

Table 1.1.2.2 (1) Detailed Description of the Monitoring Parameters in Thailand

Parameter	Method	Frequency	Note
Wet Deposition			
PH	Glass Electrode (pH Meter)	24 hrs sampling per event	
EC	Conductivity Cell		
SO ₄ ²⁻ , NO ₃ ⁻ , Cl ⁻	Ion Chromatography		
NH ₄ ⁺ , Na ⁺ , K ⁺ , Ca ²⁺ , Mg ²⁺			
Dry Deposition			
Gas			
SO ₂ , NO ₂ , NO, O ₃ , PM10	Same as Air Quality Monitoring Network		
Aerosols			
SO ₄ ²⁻ , NO ₃ ⁻ , Cl ⁻	Filter Pack – Ion Chromatography	7 days sampling per month	
NH ₄ ⁺ , Na ⁺ , K ⁺ , Ca ²⁺ , Mg ²⁺			
Soil and Vegetation			
Soil			
Moisture Content	Gravimetric Analysis	Per 3 years	Implement in Khao Laem on March, 2000
pH (H ₂ O)	Glass Electrode (pH Meter)		
pH (KCl)			
Exchangeable Base Cations (Na, K, Ca, Mg)	CH ₃ COONH ₄ -Extraction/Atomic Absorption Spectrometry		
Exchangeable Acidity	KCl-Extraction/Titration		
ECEC	Calculation		
Vegetation			
Total Sulfur	Sulfur Analyzer	Per 3 years	Implement in Khao Laem on March, 2000
Total Ca, Mg, K	Atomic Absorption Spectrometry		



Table 1.1.2.2 (2) Detailed Description of the Monitoring Parameters in Thailand

Parameter	Method	Frequency	Note
Inland and Aquatic			
Lakes			
Temperature	Thermometer	3 times per year	Implement in Khao Laem on March, August, November, 2000
PH	Glass Electrode (pH Meter)		
EC	Conductivity Cell		
Alkalinity	Titration		
NH ₄ ⁺ , NO ₃ ⁻ , NO ₂ ⁻ , PO ₄ ³⁻ , Cl ⁻	Spectrophotometry		
Na ⁺ , K ⁺ , Ca ²⁺ , Mg ²⁺	Ion Chromatography		
SO ₄ ²⁻			
Plankton	Plankton Net		
Meteorological Data			
Wind Direction/Speed	Ultra Sonic/Electric Current Meter	Continually Measure	
Temperature	Thermometer		
Humidity	Thin film		
Precipitation Amount	Rain gauge/Tipping Bucket		
Solar Radiation	Pyvanometer		

Source: PCD, modified by the Study Team

At the present, there are one monitoring network and two monitoring projects concerning acid deposition control in Thailand as shown in Table 1.1.2.3.

Table 1.1.2.3 Brief Description of Monitoring Networks for Acid Deposition in Thailand

Monitoring Program	Starting Time	End Time	Responsible Agencies
EANET Monitoring Program	1998	-	PCD
Joint Monitoring Program between PCD and Universities	2001	September, 2002	PCD King Mongkut University, Chiang Mai University, Khon Kaen University, Burapha University, Silpakorn University, Prince of Songkhla University. PCD assigned King Mongkut University management.
Joint Examination between ERTC and SERI.	2001	2003	ERTC SERI

Source: PCD and ERTC, modified by the Study Team



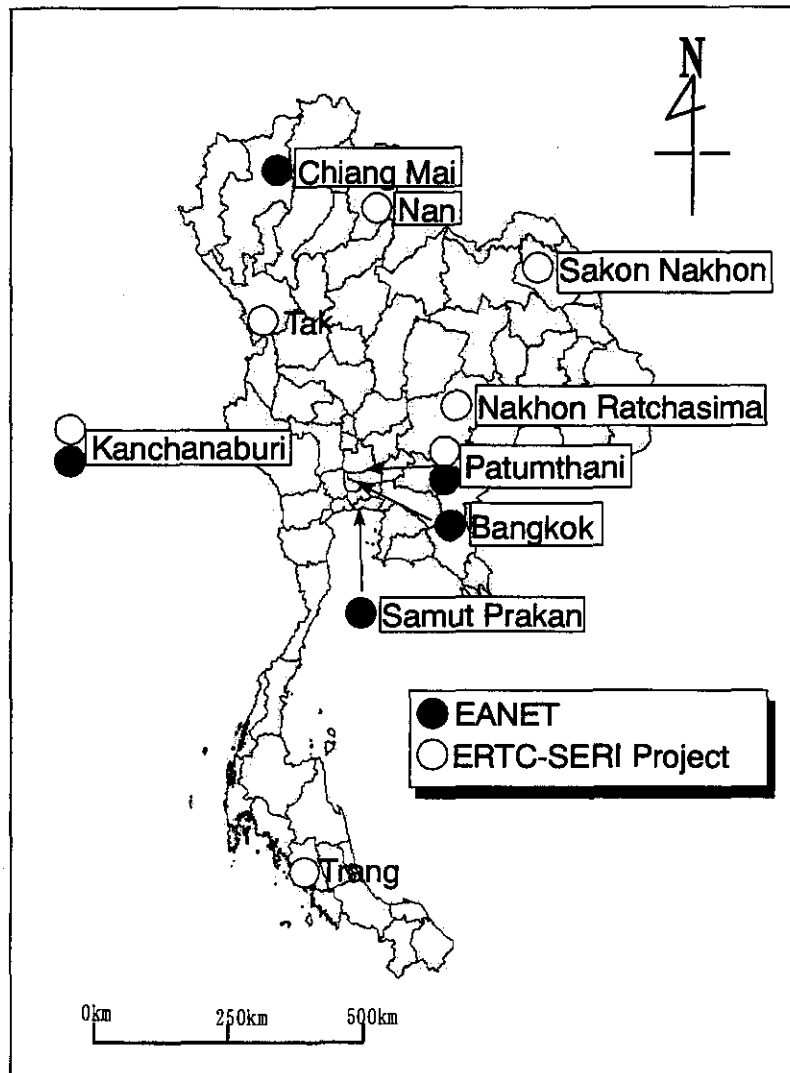
EANET monitoring system is continuously carried out. PCD has responsibilities for the EANET monitoring. PCD also has been conducting Air Quality Monitoring Network since 1992.

Brief description of EANET Program is shown in Table 1.1.2.4 in comparison with Joint Examination Program between ERTC and SERI. Locations of respective monitoring site are shown in Figure 1.1.2.1.

Table 1.1.2.4 Brief Description of EANET Network and ERTC-SERI Joint Project

		EANET Monitoring Network	ERTC-SERI Joint project
Monitoring Site		5 stations (Permanent) Bangkok, Samutprakan, Pathumthani, Kanchanaburi, Chiang Mai	7 stations (One Year) Pathumthani, Kanchanaburi, Nakorn Ratchasima, Sakorn Nakhorn, Nan, Tak, Trang
Responsible Agency		PCD, TMD, ERTC, EGAT, Chiang Mai UNV. And others	ERTC, IVL
Wet Deposition	Sampling Period	1 day or 1 event	30 Days
	Sampling Procedure	Mechanical wet only sampler	Wet-dry deposition Tree fall sampling
	Analyses Parameter	pH, EC, SO ₄ ²⁻ , NO ₃ ⁻ , Cl ⁻ , NH ₄ ⁺ , Na ⁺ , K ⁺ , Ca ²⁺ , Mg ²⁺	pH, EC, SO ₄ ²⁻ , NO ₃ ⁻ , Cl ⁻ , NH ₄ ⁺ , Na ⁺ , K ⁺ , Ca ²⁺ , Mg ²⁺
Dry Deposition	Sampling Period	Continually measure	1 month and 2 month
	Sampling Procedure	Automatically monitor, Filter pack	Passive sampler
	Analyses Parameter and Method	SO ₂ , NO ₂ , NO, O ₃ , PM, SO ₄ ²⁻ , NO ₃ ⁻ , Cl ⁻ , NH ₄ ⁺ , Na ⁺ , K ⁺ , Ca ²⁺ , Mg ²⁺	SO ₂ , NO ₂ , NO, O ₃ , PM, SO ₄ ²⁻ , NO ₃ ⁻ , Cl ⁻ , NH ₄ ⁺ , Na ⁺ , K ⁺ , Ca ²⁺ , Mg ²⁺
Soil	Sampling Period	1 time every 2 to 3 years	4 to 5 days depend on soil condition
	Sampling Procedure	Core sampling	Lysimeter collecting water sample
	Analyses Parameter and Method	Moisture content, pH, Exchangeable cation, Exchangeable Acidity, ECEC	pH, EC, SO ₄ ²⁻ , NO ₃ ⁻ , Cl ⁻ , NH ₄ ⁺ , Na ⁺ , K ⁺ , Ca ²⁺ , Mg ²⁺
Vegetation	Sampling Procedure	Sampling tree leaf	None
	Analyses Parameter and Method	Total S Total Ca, Mg and K	
Inland Aquatic	Sampling Procedure	Water sampler	None
	Analyses Parameter and Method	pH, EC, Temp., Alkalinity, Inorganic-N, PO ₄ ³⁻ , SO ₄ ²⁻ , Na ⁺ , K ⁺ , Ca ²⁺ , Mg ²⁺	

Source: PCD and ERTC, modified by the Study Team



Source: PCD and ERTC, modified by the Study Team

Figure 1.1.2.1 Acid Deposition Monitoring Site of EANET Network and ERTC-SERI Project

EANET is a permanent monitoring work in comparison with other programs, and belongs to joint network with East Asian countries. So the target of EANET monitoring network is focused on not only in Thailand but also whole area of East Asia. Therefore it is important for sustained monitoring and continuous elaboration with long term perspective.

In the other hand, ERTC has been conducting the joint project with SERI, Sweden. This program is called "Study of Possible Acidification in Thailand", and is focused on studying general acid deposition condition in Thailand. Target parameters are almost same with EANET as shown in Table 1.1.2.4. However, there is some differences in sampling method and target of the program. The target of this program is focused on natural condition, so

most of monitoring points are located in the remote area. That to say, at site selection, the effect of human activities is not focused. Monitoring sites are settled in/near natural area such as a lake or a forest. And sampling method and collectors are quite unique comparing with that of EANET. Characteristics are as follows:

- All sample collectors except air quality sampler are not mechanical;
- Rain sampling is carried out at two plots at a site, one is set outside of forest, named "Wet-Dry Sampler", and another is set in the forest, named "Tree Fall Sampler". "Wet-Dry Sampler" sampling is duplicate. And "Tree Fall Sampler" is set at 10 points each monitoring site;
- "Lysimeter" is used for sampling rain water after going through soil;
- Dry deposition is focused on horizontal direction; and
- Sampling period of rain sample and dry deposition is 30 days. Bulk sampler is covered by aluminum sheet however preservative is not used.

This program is based on different approach from that of EANET. It can provide different but important information to EANET and to the acid deposition study. Currently, the program is in monitoring phases, and interim report is being prepared. The result of this program cannot be referred at present, however it will be informative for EANET program.



1.2 Wet Deposition Monitoring Data Check by EANET Method

The purpose of collecting monitoring data is to evaluate current condition and to provide basic data for simulation of current condition. EANET Program has data checking method in its QA/QC system. Main criteria and results of checking are as follows.

1.2.1 Data Completeness

Followings are indexes of data completeness.

Percent Precipitation Coverage Length (%PCL): the percentage of measurement period in the summary period.

Total Precipitation (%TP): the percentage of valid sample amount out of the total precipitation in summary period.

By EANET Program, over 80 % of %PCL and %TP is adopted as the target value, with reference to WMO Regional Station level in the whole year.

1.2.2 Ion Balance Check

Total cation and anion value should be balanced. For this reason, Ion Balance (R1) is checked by following formula and allowable range are as follows.

$$R1 = \frac{(\text{Cation Concentration} - \text{Anion Concentration})}{(\text{Cation Concentration} + \text{Anion Concentration})} \times 100(\%)$$

Cation + Anion (ueq/L)	R1 (%)
< 50	- 30 to + 30
50 to 100	- 15 to + 15
> 100	- 8 to + 8

Measured Electrical Conductivity (EC), calculated EC value should be balanced. For this reason EC is checked by following formula and allowable ranges for R2 are as follows:

$$R2 = \frac{(\text{Calculated EC} - \text{Measured EC})}{(\text{Calculated EC} + \text{Measured EC})} \times 100(\%)$$

Measurement EC (mS/m)	R2 (%)
< 0.5	- 20 to + 20
0.5 to 3.0	- 13 to + 13
> 3.0	- 9 to + 9

1.2.3 Result of Ion Balance Check

PCD, which is network center in Thailand, carries out data validation, following the EANET procedures. When R1 or R2 exceed allowable range (Criteria), data should be checked again. Actually PCD rechecked some of data again, they tried specifying causes. According to investigation into standard calibration curves and data check sheets, following causes were estimated for exceeding of allowable range:

- Close or below the detection limit;
- Change of water quality while storing; and
- Trouble or mistake of analysis work.

However reanalyzing, which was the most suitable and basic procedure for data validation, could not carried out well in 2000 because of the lack of budget and equipment.

The result of validation of 2000 monitoring data by R1/R2 procedure is shown in Table 1.2.3.1.

Table 1.2.3.1 The Result of Data Validation by R1/R2 Procedure

Area	Bangkok	Samptplakan	Patumthani	Kantchanaburi
Monitoring Site	OEPP	TMD	ERTC	Khao Laem ¹
Total Number of Data	86	56	62	63
Number of Acceptable data for R1/R2	27	39	23	25
Ratio of Acceptable Data	31.4 %	69.6 %	37.1 %	39.7 %
Total Precipitation Amount	1144.3 mm	975.0 mm	941.3 mm	881.3 mm
Covered Ratio of Total Precipitation Amount	39.8 %	71.8 %	41.5 %	38.8 %

Source: PCD, modified by the Study Team

This result indicates that about 30 to 70 % of collected data are unacceptable in this chapter, that to say, the accepted data is able to cover only 40 to 70 % of precipitation amount.

According to QA/QC theory, unsatisfied data by validation should be rejected as unacceptable data. In this chapter, unacceptable data are rejected for the evaluation of year 2000 condition.

¹ Khao Laem Dam was renamed "Vachiralongkorn Dam" in 2001.

1.3 QA/QC System for Monitoring Network by the PCD

1.3.1 Brief description of the laboratory work

It is important to inspect not only technology and facilities but also the system to control them for proper evaluation of the monitoring network system. So, QA/QC system is considered mainly focusing on the laboratory work. This consideration is mainly by discussion and hearing with PCD staff. And it treat the laboratory system for air pollution and acid deposition, based on EANET system and general QA/QC system such as ISO/IEC 17025 system, which is for "General Requirements for the Competence of Testing and Calibration of Laboratories".

1.3.1.1 Organization

The PCD has two sub-division for monitoring air quality, that is, AQMSD I and II. AQMSD I has responsibility for operation of the monitoring networks including sampling work and evaluation of the results. Another section, AQMSD II has responsibility for laboratory work, moreover, supervising and designing some sampling work.

Concerning EANET system, the staff in AQMSD II measures chemical parameters of acid deposition sample, arranges results and submits the report to AQMSD I. The staff in AQMSD I arrange the data and evaluate the result. The responsibility for data management for the EANET is in the National Focal Point/National Center, which belongs to the PCD. And then, the chief of AQMSD finally examines the result, the director of AQNMD approves the report.

AQMSD-II has total 12 person as laboratory staff, which consists of ;

- 6 Permanent staff
- 6 Temporary staff

6 permanent staff (1 person is currently out of work) divide the main analyzing work (GC work, IC work, AAS work, UV work, PM measuring work) and general work, 6 temporary staff support as equipment operator.

Besides, AQMSD-I has total 26 person (11 person of permanent stuff and 15 person of temporary stuff).

1.3.1.2 SOPs

At the moment, the PCD uses the EANET manual as SOPs for acid deposition analysis. SOPs now are modifying from the EANET manual to the PCD's SOPs, these will be divided into each analyzing process. By the way, SOPs for Air Quality Monitoring Network are also now preparing.

First of all, operators make a draft document regarding their related work. Next, supervisors revise and submit to the chief of AQMSD. SOPs are finally approved by the director of AQMND.

1.3.1.3 External Services and Supplier

External Services and Supplier, which provide the materials for laboratory work, are selected before the procurement. Most of materials are procured from overseas. Suppliers obtain certification records from overseas, and give them to PCD. PCD can control and manage the quality of equipment and materials, and purity of reagents by the information from the suppliers.

1.3.1.4 Management of Equipment

At the moment, PCD does not have definite traceability system. Quality/purity assurance of equipment/reagents is dependent on the obtained certification record by the suppliers. The staffs, which have been trained, carry out calibration and daily maintenance. Considering electric balancer for example, operators check the balancer with a weight that has been certificated. They compare its result with the pre-set criteria as permitted level, and make a record. In the case that the result is out of criteria, the report is submitted to the related supervisors, then supervisors decide whether to request the supplier to repair or not. Another case, the result of calibration is submitted weekly.

1.3.1.5 Staff Training

All the staffs are trained for related work by related supervisors before starting to carry out laboratory works. However, at the moment, PCD does not have documents of training program, printed training procedure, frequency and responsible person. Therefore the contents and evaluation of training result is dependent on the decision of supervisors who train.

1.3.1.6 Disposition of Facilities and Rooms

PCD's chemical laboratory is divided into the Air Quality section, the Water Quality section and the Hazardous Waste section. The different divisions manage each section. Currently, the Air Quality section and the Water Quality section share the 2nd floor. Nowadays, 3rd floor is being remodeled, in the future some of the analysis room will be moved to the 3rd floor. Analysis rooms are divided each purpose such as for GC room, for IC room and for storage.

Room condition (temperature and humidity) is controlled only in the particle matter (PM10) room on the reason that PM10 is measured by gravimetric method.

1.3.1.7 Sample Acceptance

Laboratory staff belonging to AQMSD-II usually receives samples. When receiving samples, check sheets are used for identification of sample. Following items are described on the check sheets;

- Sample receiver and sample career,
- Date of sampling and receiving,
- Sampling ID, sampling station and so on.

Laboratory supervisors receive samples. Samples are preserved as its requirement in the refrigerator until starting analysis.

1.3.1.8 Sampling System

Concerning EANET system, PCD has responsibility for laboratory work in Bangkok site and Kanchanaburi site as shown in Figure 1.1.2.1. Monitoring point for EANET in Bangkok site is settled on the housetop of the PCD building. The sample in Kanchanaburi site is taken care every day by the surveyors, who belong to EGAT, and stored in the refrigerator until it carried out to PCD every one or two week. In the case of EANET, the sample in Patumthani is analyzed by ERTC, the sample in Samutprakam is analyzed by TMD. And results are submitted to the PCD every one year. Samples in Chiang Mai are taken care by King Mongkut University. Laboratory work had shared by Chiang Mai University for cation analysis and King Mongkut University for anion analysis, however, King Mongkut University has analyzed all the parameters for acid deposition since the beginning of the year 2001.

Besides, the PCD has another domestic network (Joint Network with six Universities), which covers the following 4 areas;

- Bangkok site (same as the EANET site),
- Khao Laem site (same as the EANET site),
- Lampang site (which has 2 stations) and
- Rayong site.

The PCD takes care of sampling in Bangkok site and Lampang site. The PCD staff stays Lampang site by turns. EGAT's staffs take care of Khao Laem site and Mabtapud Industrial Estate's staffs take care of Rayong site. PCD and King Mongkut University cooperate to make reports.



1.3.1.9 Evaluation and Reporting

The permanent staff concerning related work manages data quality check. Reporting form is prescribed concerning the EANET. After controlling data quality, the report is submitted to the National Center. The National Center arranges the results and makes a report. Finally the annual result is submitted to the Network Center (ADORC Japan) by the next June.



2. Socio-economic Issues

2.1 Existing Socio-Economic Conditions

2.1.1 Geography

2.1.1.1 Area

With an area of 513,115 square kilometers, Thai is located in the centre of the Southeast Asia Region. Its close neighbors are Myanmar and Laos to the north, Cambodia and Laos to the East, Malaysia and Indonesia to the South and Myanmar to the West. The southern part of the country is a peninsula that divides the Pacific Ocean (i.e. the South China Sea) and the Indian Ocean. Thai are divided into the seven areas as indicated below.

Table 2.1.1.1 Area of Regions

Unit: square kilometer						
BMR	Central	Eastern	Western	Northern	Northeastern	Southern
7,761.6	16,593.5	35,502.5	43,047.1	169,644.3	168,855.3	70,715.2

Source: Statistical Yearbook Thailand (NSO, 2000)

Most of the areas are flat and hilly. However, Thailand can be topographically divided into the three different areas below.

The plains: Mostly the plain areas are in the Central Region of the country, i.e., basins of the Chao Phraya River and its tributaries (Ping, Wang, Yom and Nan), and the Mae Klong, Phetchaburi, Bang Pakong, Thachin, and Pa Sak rivers.

The highlands: The highland areas are mostly in the Northeast, i.e., the Korat Plateau, and the plains along the Mun and Chi rivers.

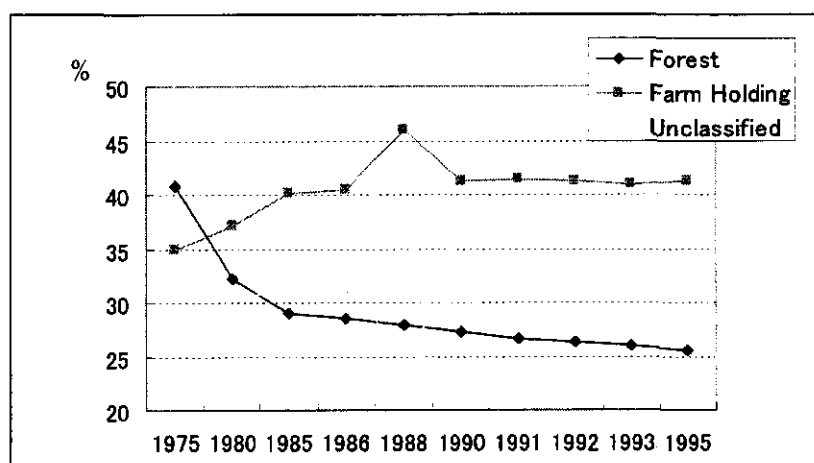
The mountains: Mostly it is mountainous in the North and the Southeast regions which cover the Ranges of Daen Lao, Luang Phra Bang, Thanon Thongchai, Phetchabun, and Tanao Si.



2.1.1.2 Land Use

Thailand had 273,000 per square kilometer of forest area in 1961. However, during the last thirty years this has been significantly depleted and reduced to 143,000 per square kilometer because of rapid expansion of the agricultural area.

According to introduction of a law for the ban on felling, the depletion of forests has slowed down as shown in Figure 2.1.1.1. Current wood coverage of land is about 131,357 per square kilometer (25.6 percent of the total land area).



Source: ESCAP, FAO, and Thai Figures 2000-2001

Figure 2.1.1.1 Land Use In the Whole Kingdom

2.1.1.3 Climate

Thailand has the following three types of climates.

Tropical rain climate in the coastal areas in the East and the South, with heavy rainfalls all year round and tropical rain forests.

Tropical monsoon climate in the southwestern and southeastern coasts with monsoons and a very high average annual rainfall.

Seasonal tropical grassland or Savannah climate with a lot of heavy rains in the southwest monsoon season and dryness in the cold season covering most regions of the country, particularly the Central, the North and the Northeast regions.

Prevailing winds include the southwestern monsoon from about mid-May to October and the northeastern monsoon from November to February.



1) Average annual temperature

Average annual temperature in Bangkok was 26.5°C in January and 28.9°C in July. As Figure 2.1.1.2 shows, the mean temperature has been increasing gradually over the last 10 years.

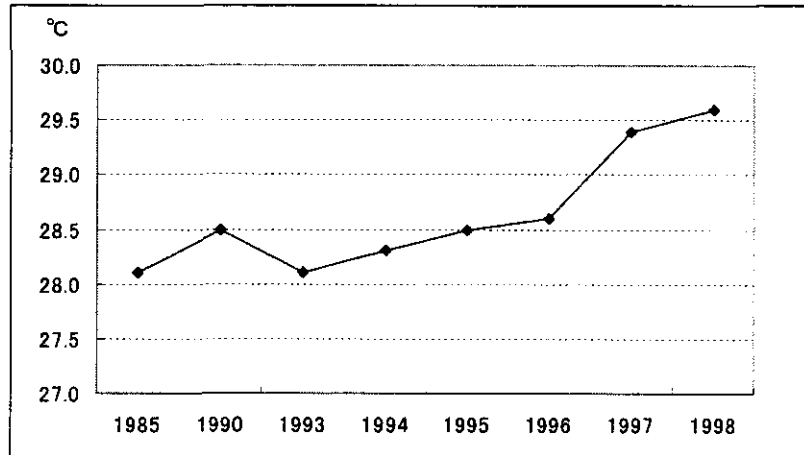


Figure 2.1.1.2 Annual Temperature in Bangkok

2) Average annual precipitation

Average annual precipitation in 1999 was about 1,492 mm in Bangkok. As Figure 2.1.1.3 shows, the average annual rainfall has increased lightly over the last decades.

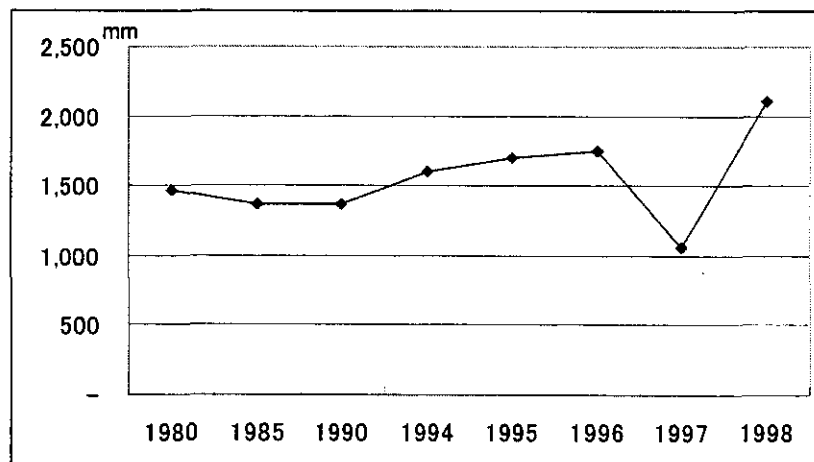


Figure 2.1.1.3 Annual Rainfall in Bangkok



2.1.1.4 Religion

The population of Thailand was 61.5 million in 1998. About 95 percent of the citizens are Thais and the rest are Chinese and Indians as well as other ethnic minorities.

For communications, the Thai language is officially and commonly used for speaking and writing, while English tends to play a greater role particularly in the business sector.

Most Thai people (92.6 percent) are Buddhists, followed by Muslims (5.3 percent) and others.

2.1.2 Demographic Conditions

2.1.2.1 Population of Thailand

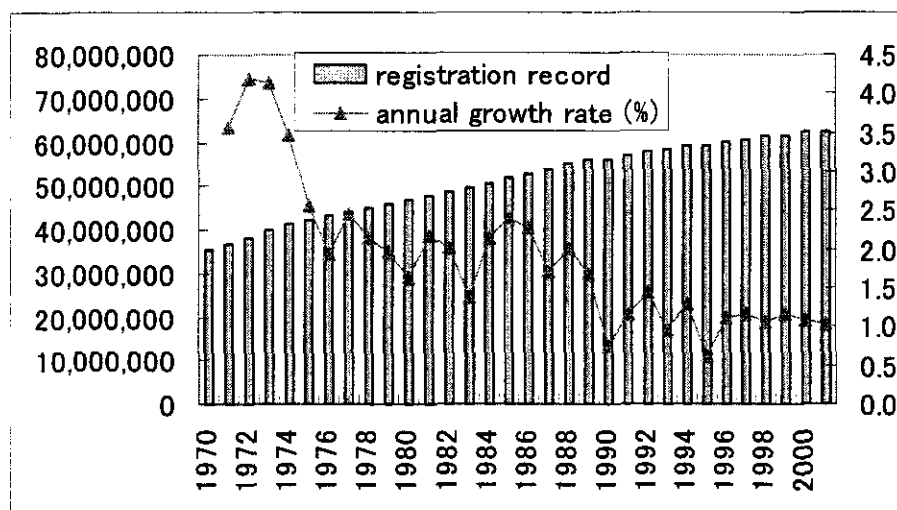
The past trend of the population of the whole kingdom and the Bangkok Metropolitan Region (BMR) which covers Bangkok metropolitan and its vicinity regions is shown in Figure 2.1.2.2. Population growth in Thailand has slowed dramatically since the mid 1970's. This has been the result of a steep decline in birth rate that has more than compensated for steady increases in life expectancy. As the smaller demographic cohorts work their way through the system, the population growth rate will continue to decline over the next 15 years.

Total population of the whole kingdom and the BMR as of 1999 are 61,660,701 and 9,308,924 respectively. Total population of the BMR is 15.1 percent of the total population of the country. These figures do not include non-registered people and actual population is about 10-20 percent more than this. As Figure 2.1.2.1 shows, the population has been steadily increasing over the last decades. But the growth ratio has been gradually decreasing during the last decades mainly due to the decrease of live births. In particular, between 1982 and 1989 the growth ration decreased drastically from 3 to 2 percent. According to data of the National Statistical Office (NSO), there is a significant disparity in demographic situation among the regions. Birth rates are significantly higher in the Northeast and South region (2.4 children per woman) than in the Central (1.7) and North (1.8) region. There is more potential for natural growth declines in the Northeast and the South regions than in the Central and the North region. In fact, the Central and the North regions currently have birth rates below the birth needed to keep the population growth stable (2.1 to 2.2 children per woman).

In addition, significant disparity in population density could be identified between urban and rural areas. As shown in Table 2.1.2.2, the average population density in the whole kingdom (as of 1999) is 120 persons per square kilometer. The most crowded province is Bangkok Metropolitan and its population density is 3,618 persons per square kilometer. The



figure is 30 times that of the whole country. Whilst, the least crowded province is Mae Hong Son (in the North Region) with a density of 18 persons per square kilometer.



Source: Website of NESDB

Figure 2.1.2.1 Trend of Population in the Whole Kingdom

Table 2.1.2.1 Trend of Population by Region

Year	Whole Kingdom	%	Central	%	Northern	%	Northeastern	%	Western	%
1919	9,207,355	100	2,870,450	31.1	1,830,496	19.9	3,253,412	35.3	1,252,997	13.6
1929	11,506,207	100	3,892,804	33.8	2,239,984	19.5	3,887,255	33.8	1,496,164	13.0
1937	14,467,105	100	4,836,461	33.4	2,836,620	19.6	4,952,288	34.2	1,841,736	12.7
1947	17,442,689	100	5,912,524	33.8	3,159,084	18.1	6,210,281	35.6	2,160,800	12.4
1960	26,257,916	100	8,271,302	31.5	5,723,106	21.8	8,991,543	34.2	3,271,965	12.5
1970	34,397,374	100	10,611,877	30.8	7,488,683	21.8	12,025,140	35.0	4,271,674	12.4
1980	44,824,540	100	14,423,343	32.1	9,074,103	20.2	15,698,878	35.0	5,628,216	12.6
1990	54,548,530	100	17,959,135	32.9	10,584,443	19.4	19,038,497	34.9	6,966,455	12.8
2000	60,606,947	100	20,421,704	33.6	11,367,826	18.8	20,759,899	34.3	8,057,518	13.0

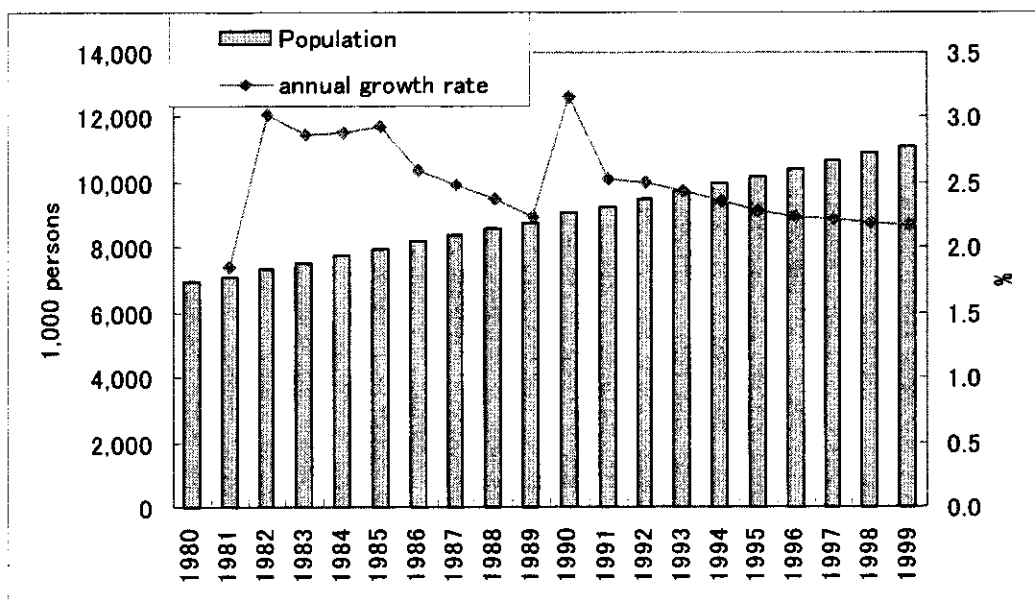
Source: Statistical Yearbook Thailand 1997, Preliminary Report of 2000 Population and Housing Census, NSO



Table 2.1.2.2 Urban Population and Population Density by Region

Region	Area (km ²)	Urban Pop. 1989	Total Pop. 1989	%	Urban Pop. 1999	Total Pop. 1999	%	Pop. Density
Northeast	168,854.3	1,129,964.0	19,575,949	5.8	1,324,771	21,379,428	6.2	126.6
Northern	169,644.3	837,171.0	10,872,752	7.7	908,768	12,124,939	7.5	71.5
Southern	70,715.2	888,772.0	6,986,250	12.7	1,163,096	8,152,638	14.3	115.3
Eastern	35,503.0	424,722.0	3,633,554	11.7	562,296	4,141,046	13.6	116.6
Western	43,047.1	320,191.0	3,269,183	9.8	338,112	3,591,191	9.4	83.4
Central	16,608.8	319,685.0	2,812,370	11.4	335,480	2,963,535	11.3	178.4
BMR	7,761.6	6,282,426.0	8,728,335	72.0	6,801,334	9,308,924	73.1	1,199.4
Whole Kingdom	513,119.5	10,202,931	55,878,393	18.3	11,433,857	61,661,701	18.5	120.2

Source: Statistical Reports of Regions (Northeast, North, South East, Sub-central, and BMR), NSO



Source: Gross Regional and Provincial Products 1981-1999 etc, NESDB

Figure 2.1.2.2 Trends of Population in BMR

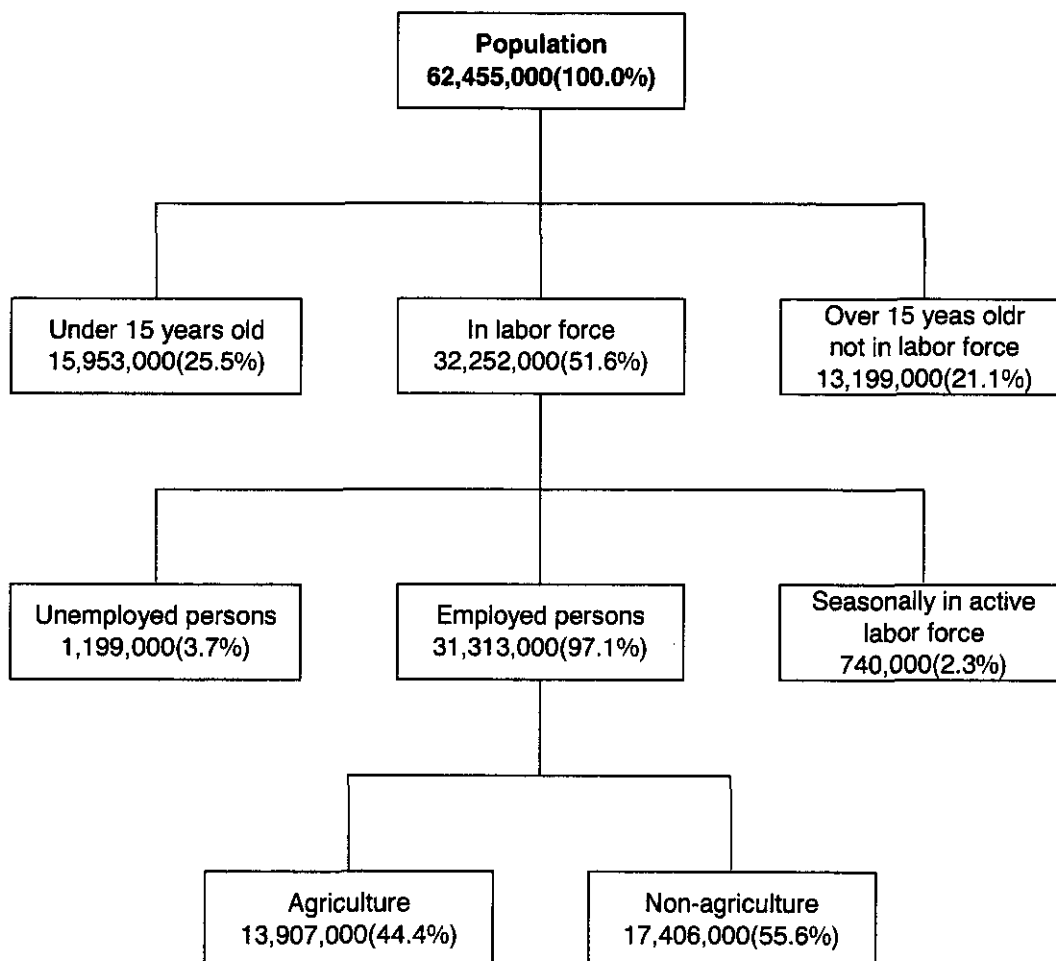


2.1.2.2 Labor Force

Labor composes of unemployed persons, employed persons and seasonally active labor forces as shown in Figure 2.1.2.3. The total labor force in Thailand is 32,252,000 as of 2000, and the figure is 51.6 percent of the total population.

The labor force in the agriculture sector has been decreasing over the last ten years. However, agricultural labor was 13,907,000 people (as of 2000) and amounts to about 50 percent of the total employed persons. It plays important roles in the national and regional economy and provides employment opportunities.

As Table 2.1.2.4 shows, after 1997 the unemployment rate was drastically increased from about 3 percent that was reflected by an economic slow-down. The rate gradually decreased and stood at 3.6 percent in 2000.



Source: Thai Figures 2000-2001

Figure 2.1.2.3 Employment Situation in the Whole Kingdom (as of 2000)



Table 2.1.2.3 Structure of Population (as of 1998)

Age Classification	Thousand	%
Total	61,248.4	100.0
Less than 13	13,982.5	22.8
13-19	8,002.3	13.1
20-29	11,377.0	18.6
30-39	9,937.3	16.2
40-49	7,672.3	12.5
50-59	4,988.3	8.1
Over 60	5,288.4	8.6

Source: Statistical Yearbook Thailand (NSO,1998)

Table 2.1.2.4 Labor Force by Sector

Year	Total labor force	Employed person	Agriculture	Mining & quarrying	Handcraft	Construction	Utility	Commerce & financial service	Transportation	Services & others	Unemployed person	Seasonally in active labor force
1992	NA	29,885	15,941	61	4,055	1,763	125	3,604	857	3,454	NA	NA
1993	NA	30,679	16,270	58	4,179	1,615	146	3,807	909	3,677	NA	NA
1994	NA	29,763	14,304	51	4,348	2,187	176	3,871	936	3,879	NA	NA
1995	NA	30,815	14,389	55	4,608	2,248	181	4,185	1,006	4,132	NA	NA
1996	32,324	31,166	14,137	54	4,651	2,649	152	4,397	995	4,097	498 (1.5%)	661
1997	32,780	31,714	14,315	52	4,644	2,502	176	4,602	1,039	4,371	495 (1.5%)	571
1998	32,409	30,104	13,454	45	4,564	1,630	196	4,611	989	4,615	1,413 (4.4%)	892
1999	32,718	30,663	13,718	64	4,597	1,400	157	4,762	1,008	4,797	1,370 (4.2%)	685
2000	32,252	31,313	13,907	44	4,994	1,486	169	4,866	979	4,868	1,199 (3.6%)	740

Source: Thai Figures: 2000-2002

2.1.3 Income level

Table 2.1.3.1 estimates the average monthly income and expenditure per family and per capita of each region and shows a disparity in income and expenditure amongst the regions. According to this analysis, the average monthly income of the whole kingdom is 12,492 baht. The BMR is classified as top with a household income of 27,424 bahts and the lowest is 9,935 bahts of the Northeastern region. In addition, according to NSO's analysis which estimates the average monthly income at per capita basis, similarly the BMR is the highest with 7,958 bahts which is about three time that of the Northeastern region.

Poverty reduction is one of the core targets in the Ninth National Economic and Social Development Plan that the NESDB set out (refer to Section 2.1.4.5). As Table 2.1.3.2 shows,



the poverty ratios in every region decreased drastically for the last two decades due to favorable economic movement. The Northeastern region's rate which was the highest of the whole kingdom and stood at 48.4 % in 1988 was decreased by half. However, 24.0 percent of people in this region were under the poverty line in 1998 and the rate was still the highest.

Table 2.1.3.1 Average Income and Expenditure per month (as of 1998)

Unit: baht

Region	Average No. per family	Average Income per month		Average Expenditure per month	
		per family	per capita	per family	per capita
Whole Kingdom	3.7	12,808	3,442	10,617	2,853
BMR *	3.4	27,424	7,958	20,947	6,079
Central	3.6	12,694	3,562	11,141	3,126
Northern	3.4	9,935	2,883	8,239	2,391
Northeastern	4.1	8,577	2,113	7,320	1,803
Southern	3.9	10,501	2,720	9,412	2,438

Source: Statistical Yearbook Thailand: Household Socio-Economic Survey (NSO, 1998)

Note: BMR includes only Nontaburi, Pathom Thani, and Samut Purakhan Provinces

Table 2.1.3.2 Poverty Ratio by Region

Year	Poverty line (baht/month per capita)	Population (million)	%	Percentage of poverty in the region (%)				
				Central	Northern	North-eastern	Southern	BMR
1988	475	17.9	32.6	26.2	32.0	48.4	32.5	6.1
1990	522	15.3	27.2	22.3	23.2	43.1	27.6	3.5
1992	600	13.5	23.2	13.3	22.6	39.9	19.7	1.9
1994	636	9.7	16.3	9.2	13.2	28.6	17.3	0.9
1996	737	6.8	11.4	6.3	11.2	19.4	11.5	0.6
1998	878	7.9	13.0	7.6	9.1	24.0	14.6	0.6

Source: Website of NESDB



2.1.4 Economic Situation

2.1.4.1 Economic Structure

In 1999, the share of the non-agricultural sector is approximately 90 percent of the total GDP, of which the industrial sector accounts for 28.6 percent. Figure 2.1.4.1 shows the overall trend of changing economic structure between 1991 and 1999.

1) Agriculture

The share of the agriculture sector had been declining up to the year 1996. After 1997 the figure increased which was mainly reflected by the economic recession in Thailand. In 1999 the share is 10.5 percent, which is relatively small. However, agricultural labor consisted of 13,907,000 people (as of 2000) and amounts to about 50 percent of the total employed persons. Agriculture activities expect to play important roles in supporting and boosting national and regional economy, and providing employment opportunities.

2) Manufacture

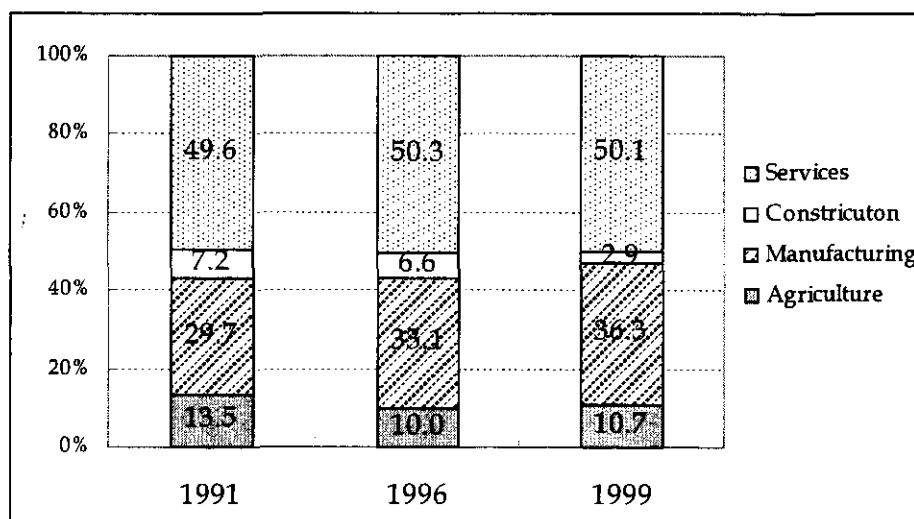
The share of the economy in the manufacturing sector has been increasing steadily over the past 20 years and presents 36.3 percent of GDP in 1999. The NESDB expects that the share will increase constantly in the future.

3) Construction

The share of the economy in the construction sector was 7.2 percent in 1991 but it drastically declined from 1997 and reached 2.9 percent in 1999. This overall decline is mainly reflected by the economy slow-down.

4) Services

The share of economy in the service sector is 50 percent, the internal composition of this sector is changing drastically. The importance of personal service is declining, while knowledge (professional and business) services and tourism are increasing.



Source: National Income of Thailand, 1951-1996 Edition (NESDB)

Figure 2.1.4.1 Economic Structure (as percent of GDP)

2.1.4.2 Regional Economy

There are major regional disparities in wealth in Thailand. These disparities were accentuated by the economic downturn in the years 1997 and 1998. Population is not as concentrated in Bangkok as would be anticipated given the fact that 49% of GDP is generated in the BMR including Bangkok and the vicinity region (Table 2.1.4.1 and Table 2.1.4.3). GRP per capita of the BMR is more than five times the Northern region, and approximately four times that of the Southern region (Table 2.1.4.2).

Table 2.1.4.1 Population by Region

Unit: 1,000

Region \ Year	1993	1994	1995	1996	1997	1998	1999p
Northeastern	19,866	20,062	20,246	20,405	20,573	20,733	20,904
Northern	10,992	11,057	11,121	11,149	11,171	11,200	11,214
Western	7,630	7,743	7,854	7,961	8,059	8,157	8,253
Eastern	3,658	3,710	3,756	3,805	3,851	3,890	3,942
Southern	3,277	3,312	3,343	3,370	3,396	3,421	3,451
Central	2,844	2,856	2,880	2,884	2,892	2,906	2,911
BMR	9,743	9,973	10,201	10,429	10,660	10,894	11,131
Whole Kingdom	58,010	58,713	59,401	60,003	60,602	61,201	61,806

Source: JICA study team calculated based on the data from NESDB



Table 2.1.4.2 GDP per capita by Region

Unit: thousand bahts

Region \ Year	1993	1994	1995	1996	1997	1998	1999p
Northeastern	13,660	14,929	16,350	17,092	16,338	14,863	15,132
Northern	20,888	22,247	23,543	25,119	24,075	22,630	22,959
Western	28,220	30,525	32,674	34,274	33,353	31,706	31,191
Eastern	63,803	71,300	81,459	93,558	101,952	95,215	100,383
Southern	32,213	34,023	37,061	37,713	36,472	32,655	33,803
Central	38,211	43,911	47,932	52,245	51,364	44,540	46,444
BMR	134,457	141,478	149,877	151,903	144,058	120,396	124,013
Whole Kingdom*	42,647	45,908	49,599	51,991	50,733	44,825	46,260

Source: JICA study team calculated based on the data from NESDB

Note: * means the average of whole kingdom

Table 2.1.4.3 GDP by Region

Unit: million bahts

Region \ Year	1993	1994	1995	1996	1997	1998	1999p
Northeastern	271,376	299,498	331,015	348,758	336,114	308,152	316,323
Northern	229,606	245,982	261,825	280,048	268,942	253,452	257,459
Western	215,319	236,357	256,623	272,859	268,794	258,626	257,419
Eastern	233,393	264,524	305,960	355,989	392,617	370,387	395,711
Southern	105,561	112,685	123,894	127,093	123,858	111,713	116,653
Central	108,672	125,410	138,045	150,676	148,545	129,432	135,199
BMR	1,310,011	1,410,956	1,528,891	1,584,199	1,535,656	1,311,597	1,380,394
Whole Kingdom	2,473,939	2,695,412	2,946,252	3,119,621	3,074,528	2,743,359	2,859,157

Source: JICA study team calculated based on the data from NESDB

Note: p means preliminary value

Table 2.1.4.4 GDP Growth Rate by Region

Unit: per cent

Region \ Year	1994	1995	1996	1997	1998	1999p	Average
Northeastern	10.4	10.5	5.4	-3.6	-8.3	2.7	2.8
Northern	7.1	6.4	7.0	-4.0	-5.8	1.6	2.1
Western	9.8	8.6	6.3	-1.5	-3.8	-0.5	3.2
Eastern	13.3	15.7	16.4	10.3	-5.7	6.8	9.5
Southern	6.7	9.9	2.6	-2.5	-9.8	4.4	1.9
Central	15.4	10.1	9.2	-1.4	-12.9	4.5	4.1
BMR	7.7	8.4	3.6	-3.1	-14.6	5.2	1.2
Whole Kingdom	9.0	9.3	5.9	-1.4	-10.8	4.2	2.7

Source: JICA study team Calculated based on the data from NESDB

Note: p means preliminary value



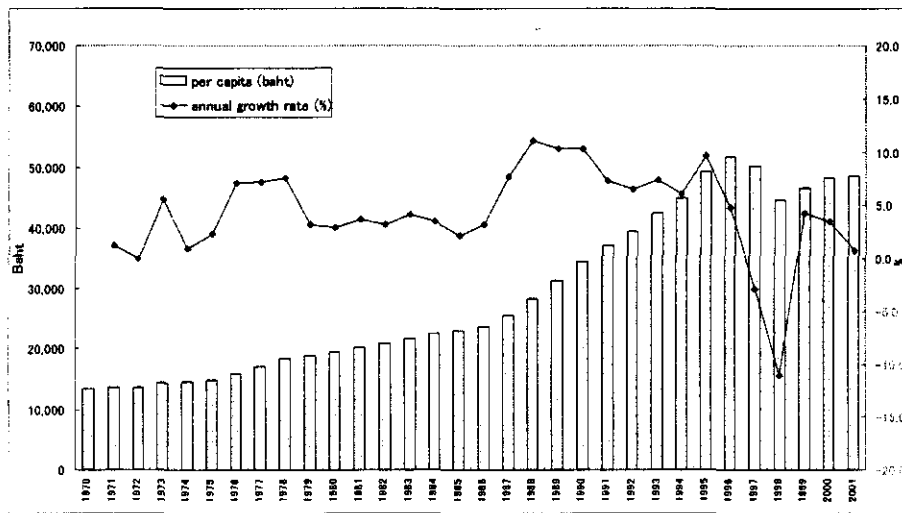
2.1.4.3 Economic Trends of Thailand

Thailand's economic growth between 1984 and 1995 was one of the fastest in the world (refer to Figure 2.1.4.2). Its peak was in year 1988 when the GDP growth ratio reached 13.5 percent. Average annual GDP growth during the period between 1992 and 1996 (the Seventh Economic and Social Development Plan) was 8.1 percent.

This rapid development was fed mainly by successful growth in manufacturing, pushed by enormous foreign direct and domestic investment. At the same time, from the late 1980's knowledge economy in Bangkok grew rapidly, while agricultural activities grew rather steadily. This period is known as the 'Golden Age of Manufacturing' and started with the Baht devaluation.

The economy slowdown began in 1997 caused by a failure of Thailand's economy to restructure fast enough to respond to changing external conditions, in particular, the growth of lower cost competitors, the decline in demand in the developed countries and the decline in the value of the Yen. The economic crisis had peaked in March 1999 and began to gradually recover during the last quarter of fiscal year 1999. During the second period, from March to May 1999, economic problems and financial liquidity still remained in a critical condition. The government had introduced new stimulus measures including the stimulation of public spending, and the creation of job programs in all regions across the country. In order to spur more spending tax and energy policies were implemented such as the reduction of value added tax, cuts of excise tax on fuel oil, the government's subsidy to maintain cooking gas prices, and the exclusion of certain cost elements from the automatic adjustment mechanism resulting in lower electricity tariffs.

Due to the above countermeasures, the economy began to show positive signs of gradual recovery, particularly in the export sector as shown in Table 2.1.4.5. In fact, the exports of manufactured and industrial products began to expand and therefore foreign investors had more confidence in the Thailand's economic restoration programs. The Thai baht currency became more stabilized and the inflation rate also decreased (refer to Table 2.1.4.5). Although private investment has started to pick up, it is confined to certain sectors at present, which is limiting economic growth.



Source: National Income of Thailand (NESDB, 2002)

Figure 2.1.4.2 GDP per capita at 1998 prices and Annual Growth Rate

Table 2.1.4.5 Key Indicators of Economic Trends

Key indicators	Year	1997	1998	1999	2000	2001
Real Economic Growth Rate (%)		-1.8	-10.4	4.0	4.3	1.8
Expenditure (%)		5.9	-12	3.5	4.9	3.0
Investment (%)		6.6	-38.1	-4.0	5.4	3.0
Inflation rate (%)		5.6	8.1	0.3	1.6	2.0
Export Value (billion US dollar)		567	529	568	679	632
(growth rate: %)		(3.7)	(-6.8)	(7.4)	(19.5)	(-6.9)
Import Value (billion US dollar)		613	406	475	624	607
(growth rate: %)		(-13.4)	(-33.8)	(16.9)	(31.3)	(4.5)
Current Account Balance (billion US dollar)		-31	143	125	92	44
Current Account Balance/GDP (%)		(-0.9)	(12.8)	(10.2)	(7.5)	(3.6)
Foreign Currency Change Reserve (billion US dollar)		270	295	348	327	—
Fiscal balance/GDP (%)		2.2	-3.0	-5.5	-5.0	—

Source: Central Bank of Thailand and NESDB etc.

The 1980's moved away from the traditional agricultural industry to a more export oriented manufacturing industry based upon labor intensive items such as textile and garments. After 1990, the fast growing market was technological industries such as computer accessories and motor vehicles.

Table 2.1.4.6 GDP Growth Rate by Sector 1995-1999 (%)

Sector \ Year	1995	1996	1997	1998	1999p	Average
Agriculture	3.56	3.79	-0.67	-3.10	2.57	1.23
Manufacturing	12.45	6.71	1.58	-11.44	11.92	4.25
Construction	6.95	6.87	-26.40	-38.95	-5.38	-11.38
Services	7.17	7.08	2.11	-0.37	5.47	4.29
Other	9.47	5.38	-1.01	-11.61	-0.90	0.27
Whole Kingdom	9.31	5.88	-1.45	-10.77	4.22	1.44

Source: NESDB

2.1.4.4 Import/Export

The main engine of economic growth for several decades has been Thailand's exports, since economic policy in Thailand moved from an import substituting policy to a strategy more closely based upon a market.

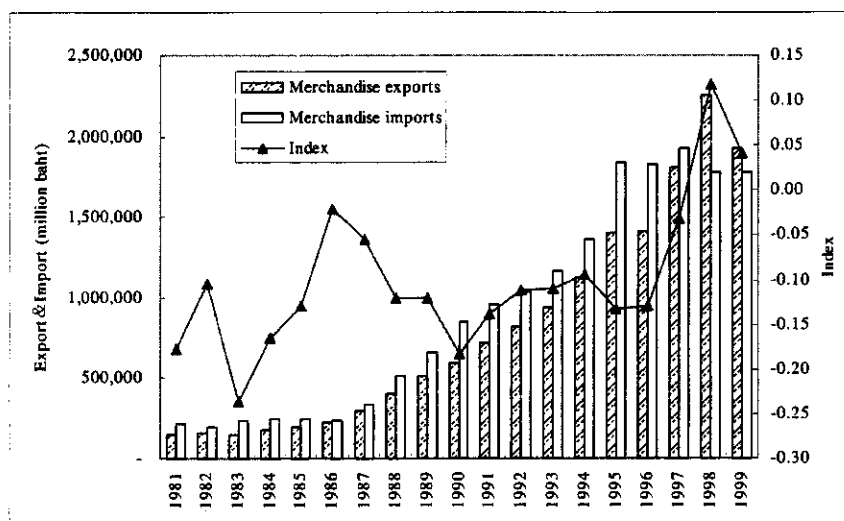
According to the Economy Monitor (World Bank, 2001), the major exporting commodities are foods which earn 3,186 million baths and is ranked top, following materials and fuels, manufactured products, and fish and aquatic products. The total export value of goods was estimated at 1,924,281 million baht in 1999. While the major importing commodities were food, machinery, vehicle and equipment etc. The total import value in 1999 was estimated at 1,774,076 million baht.

In 1984, Thailand adopted an aggressive export-oriented development strategy that proved very successful. As indicated in Figure 2.1.4.3 between 1986 and 1998 the exports grew by an average annual rate of 21.1 percent. However, the exports decreased in both volume and value at the rate of 10.6 and 11.1 percent respectively from 1998, which was mainly caused by the decline in almost every major exporting commodity and in every exporting market except for Chinese and Korean markets. As Figure 2.1.4.3 shows, the index value reached 0.12 in 1998, and was turned over from minus to plus. This indicates that the Thai economy became highly dependent upon export markets.

As the Ninth Economic and Social Development Plan (2002-2006) targets annual expansion at the average rate of 6 percent, export of food production is more encouraged as good potential productions to drive the country's economy. According to the Department of Export Promotion, food exports in 2002 are expected to grow by 8 percent. The world economic growth is projected at 3.9 percent and the global trade is likely to expand by 6.5 percent this year. The expected increase in both the world economy and trade will result in more food consumption. The increase of export will provide greater opportunities for



Thailand to export more food products. In particular, the policy would expect to support small- and medium-sized enterprises in the food industry.



Note: Index = (Export value - Import value)/(Export value + Import value)
 Source: Thai Figures 2000-2001

Figure 2.1.4.3 Changes in Trade Structure

2.1.4.5 The Ninth National Economic and Social Development Plan and Economic Targets

The Ninth National Economic and Social Development Plan (2002-2006) formulated by the NESDB has commenced, in which the following four major items are targeted;

- 1) Balanced Economic Development
- 2) Quality of Life
- 3) Good Governance
- 4) Poverty Alleviation

According to the plan, annual economic growth is planned to attain 4-5 percent with an average annual current account surplus of approximately 1-3 percent of GDP. Labor productivity is expected to increase at 3 percent annually. The annual growth of population is projected at less than 3 percent.

The total factor productivity in the agriculture and industrial sectors is set to grow at an annual average rate of 0.5 percent and 2.5 percent, respectively.

As for the objectives of economic development, the following points are focussed on;

- Stable and sustainable economic development is required.



- The economy should be strong and self-reliant at grassroots level.
- The government is committed to strengthen the financial sector and fiscal position of the country with economic restructuring.

Table 2.1.4.7 summaries the short-term targets of macroeconomic up to the year 2006 for the Thai economy set by the NESDB.

Table 2.1.4.7 Macroeconomic Target by NESDB

Items	Year							Average 2002-06
	2001	2002	2003	2004	2005	2006		
GDP Growth Rate (%)	2.5	4.0	5.3	5.6	6.0	6.0	5.4	
GDP (Billion Baht, current price)	5,116	5,454	5,879	6,361	6,908	7,502	-	
Inflation (%)	2.3	2.6	2.6	2.6	2.6	2.6	2.6	
Current Account as % to GDP	3.1	1.9	1.6	1.3	0.8	0.4	1.2	

Source: Strategy Plan Framework Toward Quality and Sustainability of Thailand Economic Development, Ministry of Finance, as of July 15, 2001



2.1.5 Administration

2.1.5.1 Structure and functions

Central administration, comprising the office of the Prime Minister, 19 ministries and 28 Ministers constituting a Cabinet (refer to Box 1 and Figure 2.1.5.1).

The country is administratively divided into 76 provinces (as of 1999). A governor and his deputies head the administration of a province. The provinces are administratively divided into a number of districts, headed by district officers falling under the responsibilities of the provincial governor. A district is divided into subdistricts (Tambon) is headed by a subdistrict chief (Kamnan). A

subdistrict consists of several villages, headed by village heads.

Local administration or local government, taking five different forms whose characteristics are described in Box 2 and Table 2.1.5.1. According to the Provincial Administrative Law, the provincial administration consists of 75 provinces (Changwat), 795 districts (Amphoe) and 81 subdistricts (King Amphoe). Provincial administrations are staffed by provincial governors and district officers, under the authority of the provincial administration. The local administration and provincial administration are to some extent overlapping.

In Thailand, the administrative power is highly centralized at the level of the central administration. The provincial governors and district officers are the major authorities in the provincial administration and act as the representatives of the central government in the provinces. However, the decentralized scheme has commenced from a few years ago and the concentrated powers are delivered to the local government as mentioned the details in Section 2.1.5.2

<Box 1: 18 Ministries in Thailand
as of February 23, 2003>

1. Ministry of Finance
2. Ministry of Foreign
3. Ministry of Tourism and Sports Minister
4. Ministry of Social Development and Human Services
5. Ministry of Agriculture and Cooperatives
6. Ministry of Transport Minister
7. Ministry of Natural Resources and Environment
8. Ministry of Information and Communications Technology
9. Ministry of Energy
10. Ministry of Commerce
11. Ministry of Defence
12. Ministry of Interior
13. Ministry of Justice
14. Ministry of Labor
15. Ministry of Culture
16. Ministry of Science and Technology
17. Ministry of Education
18. Ministry of Public Health
19. Ministry of Industry



2.1.5.2 Local Government Categories and Hierarchies

Local governments in Thailand is categorized in the Five (5) different forms; equally distributed among urban and rural areas.

The details of the five forms are summarized in Box 2 below.

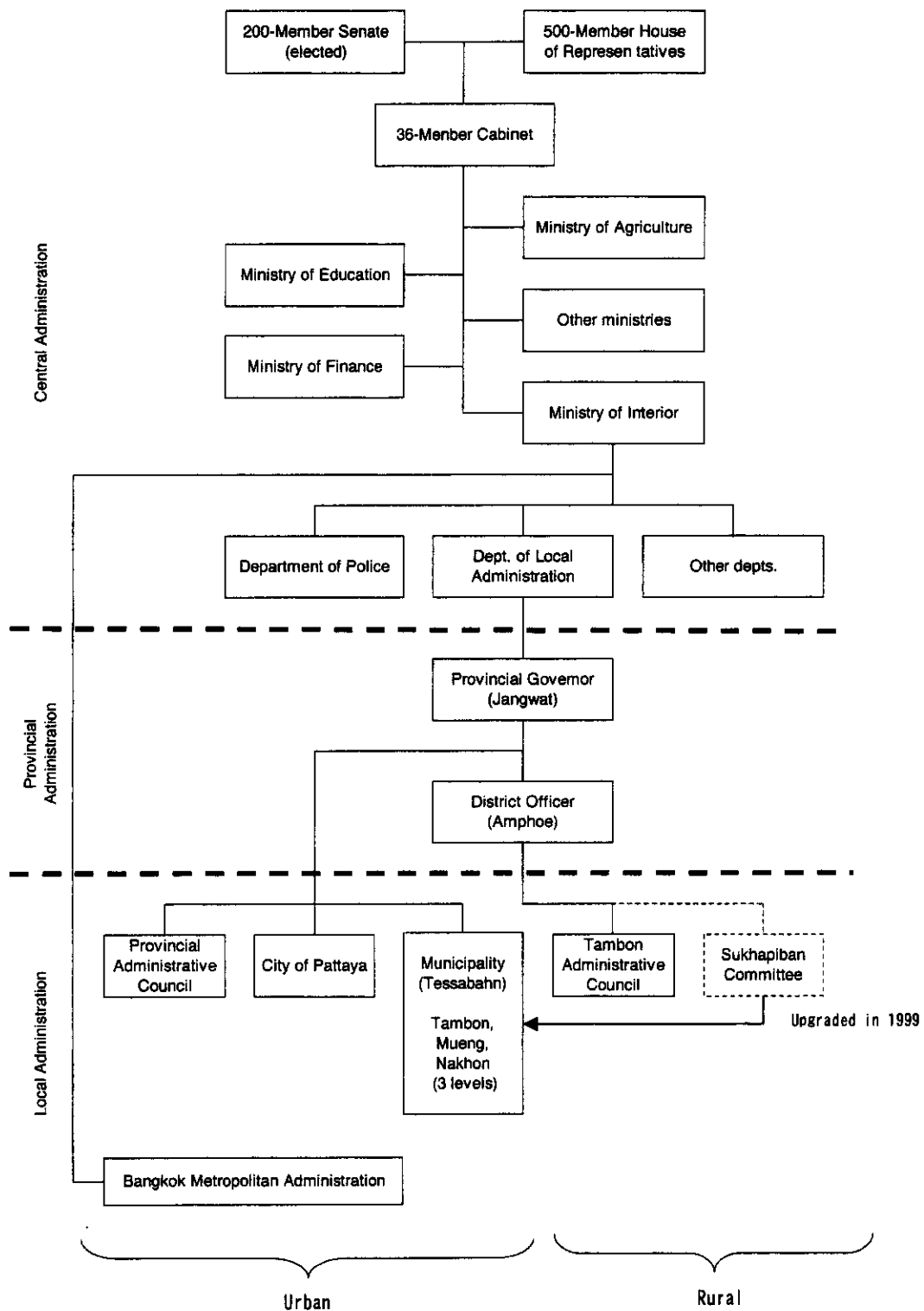
<Box 2: Five Forms of Local Government>

Urban-based forms:

1. **Bangkok Metropolitan Administration (BMA):** a strong-executive form of local government specific to Bangkok
2. **Municipality:** governing urban centers in the provinces
3. **City of Pattaya:** a local government form of a city-manager specific to Pattaya. The Government of this city takes the form of a council-manager. This form of local government has only been experimented with in Pattaya.

Rural-based forms:

1. **Provincial Administrative Organization (PAO):** comprises an elected provincial council that functions as a legislative branch and an executive board. Until 1997 the provincial governor was by law the chief executive of a PAO.
2. **Tambon Administrative Organization (TAO):** is a rural administrative division at a subdistrict level comprising of a few villages. Since 1972, every *Tambon* in the country has a *Tambon* council, a consultative body that gives advice to the chief of a *Tambon*.



Source: Department of Local Administration, Ministry of Interior

Figure 2.1.5.1 Governmental Structure



Table 2.1.5.1 Forms and Characteristics of Local Government

Type	Forms of Local Government	Size and Population	Chief Executive	Legislative
Urban	1. Bangkok Metropolitan Administration (BMA)	1,565 km ² population 62,308,887. divided into 50 districts.	governor, directly elected by popular votes; who appoints 4 deputies, and 38 district officers	38- member council elected by popular votes; each district has a 7-member council elected by popular votes
	2. Municipality (1,129 as of September 2001 in 3 categories)		mayor, elected by the council,	council elected by popular votes for a 4-year term
	2.1 Tambon Municipality (1,029 as of September 2001 in 3 categories)	population > 7,000 pop. density - 1,500/km ² revenue > 12 M Bt/year	mayor, elected by the council; the mayor appoints 2 executives	12-member council elected for a 4-year term
	2.2 Town Municipality (80 as of September 2001)	population > 10,000; pop. density > 3,000/km ² revenue: compatible with responsibility	mayor elected by the council, the mayor appoints 2 executives	18-member council, elected for a 4-year term
	2.3 City Municipality (20 as of September 2001)	population > 50,000 pop. density > 3,000/km ² revenue as compatible with responsibility	mayor elected by the council, the mayor appoints 4 executives	24-member council, elected for a 4-year term
	3. The City of Pattaya	population 29,000; 208 km ² 22 km ² in city, 186 km ² on 3 islands	manager employed on 4 year-contract, who appoints 2 deputy managers	17-member assembly, 9 elected, 8 appointed for 4 years' term
Rural	4. Provincial Administrative Organization (PAO) (76 as of 1999)	provincial, population varies to size	provincial governor* appointed by the minister of interior, who appoints 1 deputy	assembly elected for a 4-year term,* size varies to population i.e. 24, 36, 42 and 48 members
	5. Tambon Administrative Organization (TAO) (6,745 as of 1997)	population varies to size	a kamnan or subdistrict chief, appointed by provincial governor	a council partly appointed from subdistrict chiefs and all village heads, partly elected 1 from each village

Source: Department of Local Administration, Ministry of Interior

*The Provincial Administration Organisation Act (1997) states the Provincial Administration Assembly to elect the chief executive of the PAO and reduces the Assembly's term to 4 years



2.1.5.3 Decentralization

A law called 'Plan and Step for Decentralization' was enacted in a constitutional amendment (in 1997) aiming at decentralization promotion. Then, the government started to introduce the decentralization scheme national wide in addition to three local governments called 'Tesaban' which have already been applied autonomous government system and are administrated by elected governors democratically. It is expected that local government particularly local urban government would be given more financial and decision making autonomy by the decentralization scheme.

This policy does not mean that all functions of the central government will be handed over to the local governments. National scale infrastructure will continue to be delivered directly or indirectly to the central government. Whilst, much local scale civil, environment and economic infrastructure will be delivered by local governments who will have greater access to finance, particularly credit.

The current problems encountered in these provinces are that there are significant disparities on knowledge and technical skills between central and local governments. Therefore, capacity building needs to be initiated or should be parallel with the encouraging activities.

The followings are core decentralization strategies formulated by the Office of the Council of the State.

- (1) Placing an emphasis on local revenue collection and decentralization of fiscal power to local authorities in order to achieve budget management that is more independent, taking into consideration the needs and appropriateness for development of the localities.
- (2) Encouraging clear, appropriate and stepwise decentralization of power from the central government to the local authorities. At the same time, the potential of local civil service administrations and local governmental organizations must be strengthened and further developed in line with the activities of each locality. There must be greater independence with regard to local budget management and allocation, income acquisition and management of local properties.
- (3) Encouraging the local people, civil society and private organizations to participate in local administration, thereby providing for inspection, monitoring, and evaluation of the local administration. Such participation ranges from the decision-making process, policy formulation, and procurement to the appointment and removal of the local authorities for the sake of transparency and efficiency as well as in response to the needs of the local people. Promote better understanding with regard to the roles and responsibilities of all the



organizations concerned so that the local decentralization process can proceed in an effective manner.

2.1.5.4 Government Finance

1) Central Government

Table 2.1.5.2 indicates changes in budget share (including transfer to state enterprises) over the last nine years. Top five ministries in terms of expenditure are: Ministry of Education, Interior, Agriculture and Public health, and the shares are 17.7, 11.7, 8.5, 7.5 and 5.3 percent, respectively in 2001. Most of them were cut down because of economic stagnation during the period. The largest cuts were shouldered by the Ministry of Interior, Transport and Communication, Agriculture, and Defense. In particular, the share of Ministry of Interior and Defense were constantly decreased up to the year 2001.

Measured in terms of share of the budget, over the eight five-year development period (1996-2001), Ministry of Finance, Science, Technology and Environment, Education and Labor and Social Welfare show the largest increase, leading up to the present. The budget share of Ministry of Finance was increased drastically after decrease up to the year 1998 due to IMF conditions.

In order to increase of tax revenue, the current taxing system is going to be improved. The targeted ratio of tax revenue to national GDP in year 2006 is 16.7 percent, as shown in Table 2.1.5.2 and Table 2.1.5.3. The budgets of MOSTE, PCD and AQNMD are shown in Table 2.1.5.4 and Table 2.1.5.5. The budget of AQNMD is going down for the last 5 years.



Table 2.1.5.2 Percentage Share of Fiscal Budget

Ministry	Percentage of Share							Change in Share	
	1995	1996	1997	1998	1999	2000	2001	1995-1998	1998-2001
Central Fund	13.6	10.6	9.3	9.5	9.3	8.9	9.6	-4.1	0.1
Office of Prime Minister	1.0	1.0	0.9	0.8	0.8	0.9	0.8	-0.2	0.0
Ministry of Defence	12.8	11.9	11.1	9.9	9.3	9.0	8.5	-2.9	-1.4
Ministry of Finance	6.9	5.8	5.4	5.2	9.1	8.9	10.6	-1.7	5.4
Ministry of Foreign Affairs	0.5	0.5	0.4	0.5	0.5	0.5	0.4	0.0	-0.1
Ministry of Agriculture and Cooperatives	8.9	8.8	8.4	7.9	7.9	8.0	7.5	-1.0	-0.4
Ministry of Transport and Communications	7.6	8.1	8.5	8.9	6.9	5.8	5.3	1.3	-3.6
Ministry of Commerce	0.4	0.5	0.4	0.5	0.5	0.5	0.5	0.1	0.0
Ministry of Interior	14.9	18.1	18.6	16.8	11.9	11.1	11.7	1.9	-5.1
Ministry of Justice	0.4	0.5	0.5	0.7	0.6	0.7	0.8	0.3	0.1
Ministry of Labor and Social Welfare	1.2	1.3	1.3	1.2	1.3	2.0	1.9	0.0	0.7
Ministry of Science, Technology and Environment	1.1	1.3	1.3	1.4	1.4	1.5	1.4	0.3	0.0
Ministry of Education	15.5	15.8	16.9	18.5	18.4	18.5	17.7	3.0	-0.8
Ministry of Public Health	6.3	6.6	7.0	7.5	6.9	6.8	6.5	1.2	-1.0
Ministry of Industry	0.6	0.6	0.5	0.5	0.5	0.5	0.4	-0.1	-0.1
Ministry of University Affairs	3.5	3.7	3.9	4.0	4.2	3.9	3.5	0.5	-0.5
Independent Public Agencies	0.5	0.6	0.5	0.6	5.2	5.5	5.2	0.1	4.6
Independent Bodies under the constitution						0.2	0.4	0.0	0.4
State Enterprises	2.6	2.8	2.7	3.2	2.6	2.8	3.6	0.6	0.4
Revolving Fund	1.7	1.6	2.4	2.5	2.7	3.9	3.8	0.8	1.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0		

Source: JICA study analyzed using data from Thai Figure 2000-2001

Table 2.1.5.3 Targeted Government Budget

Unit: Billion Baht	2001	2002	2003	2004	2005	2006
Cash Balance						
1. Forecast Expenditures (cash)	906.0	1,010.9	1,074.1	1,132.4	1,218.3	1,289.3
Percentage of GDP (%)	17.7	18.3	18.2	17.7	17.5	17.0
Growth (%)	5.4	11.6	6.2	5.4	7.6	5.8
2. Tax and Regular Revenue	777.7	807.8	914.6	1,026.3	1,153.8	1,262.6
Percentage of GDP (%)	15.2	14.6	15.5	16.0	16.6	16.7
Growth (%)	4.0	3.9	13.2	12.2	12.4	9.4
3. Revenue from Managing State-owned Enterprises' Asset	24.6	60.6	636.6	77.4	77.4	77.4
4. Total (2+3)	802.3	868.8	978.2	1,103.7	1,231.3	1,340.0
5. Cash Balance	-115.0	-172.8	-127.6	-67.5	-25.8	11.0
Percentage of GDP (%)	-2.2	-3.2	-2.2	-1.1	-0.4	0.2
6. Value of Assets held by Ministry of Finance	1,826.7	2,198.5	2,476.7	2,340.9	2,355.3	2,397.5
Public Debt						
7. Debt Service/Government Budget (%)	10.9	11.3	16.0	15.6	16.4	16.0
8. Public Sector/GDP (%)	57.2	58.7	56.8	53.2	50.8	47.0

Source: Strategy Plan Framework Toward Quality and Sustainability of Thailand Economic Development, NESDB and MOF, as of July 15, 2001



Table 2.1.5.4 Budgets of MOSTE, PCD, and AQNMD

Unit: million bahts

	MOSTE	PCD	AQNMD
1997	13,750.9	1,363.6	253.6
1998	12,129.9	530.4	84.4
1999	11,954.8	252.2	75.8
2000	11,384.5	224.4	87.6
2001	12,828.8	232.0	85.6
2002	NA	194.1	70.0

Note: Term of Fiscal year is October-September

Source: Questionnaire survey conducted by JICA in 2001

Table 2.1.5.5 Expenditures of MOSTE (as of 1999)

	Salaries and Wages	Temporary Wages	Remuneration on Services other than personal supplies	Public Utilities	Equipment properties and Construction	Subsidies	Others	Total Expenditure
million baht	831.3	130.0	322.1	66.0	3,277.2	7,502.2	517.2	12,646.0
%	6.6	1.0	2.6	0.5	25.9	59.32	4.19	100.0

Source: PCD

2) Local Government

Financing of local government involves planning and two kinds of management activities: revenue collection and expenditure.

(1) Development Planning

Based upon the policy guidelines the executive local government unit formulates its annual and five-year development plan complying the socio-economic development plan of NESDB. The plan serves as a general framework, within which annual budgeting is prepared.

(2) Revenue collection and Budgeting

Normally local government units plan their administrative and development expenditures well within the limit of the expected revenues. Budgeting of development projects has to be in line with the annual and five-year development plans. The chief executive will submit the annual budget to the legislative branch of local government for debate and approval well before the beginning of the next fiscal year.

Once the annual budget is passed in the form of a local government ordinance, the local government unit will collect revenues as specified by concerned laws and regulations. All units of local government draw their revenues from the four main sources (refer to Box 3).



<Box 3 Main Revenue Sources of Local Governments>

- Local government taxes;
- Fees, Licenses, Fines;
- Revenues from properties, public utilities and local government enterprises; and
- *Donations, Grants, Loans and Subsidies from the central government.*

Further, the local government taxes (refer to Figure 2.1.5.2) are classified into the following three categories:

Category 1: Taxes collected by local governments

These include housing tax, land tax, signboard tax and slaughtering tax as below.

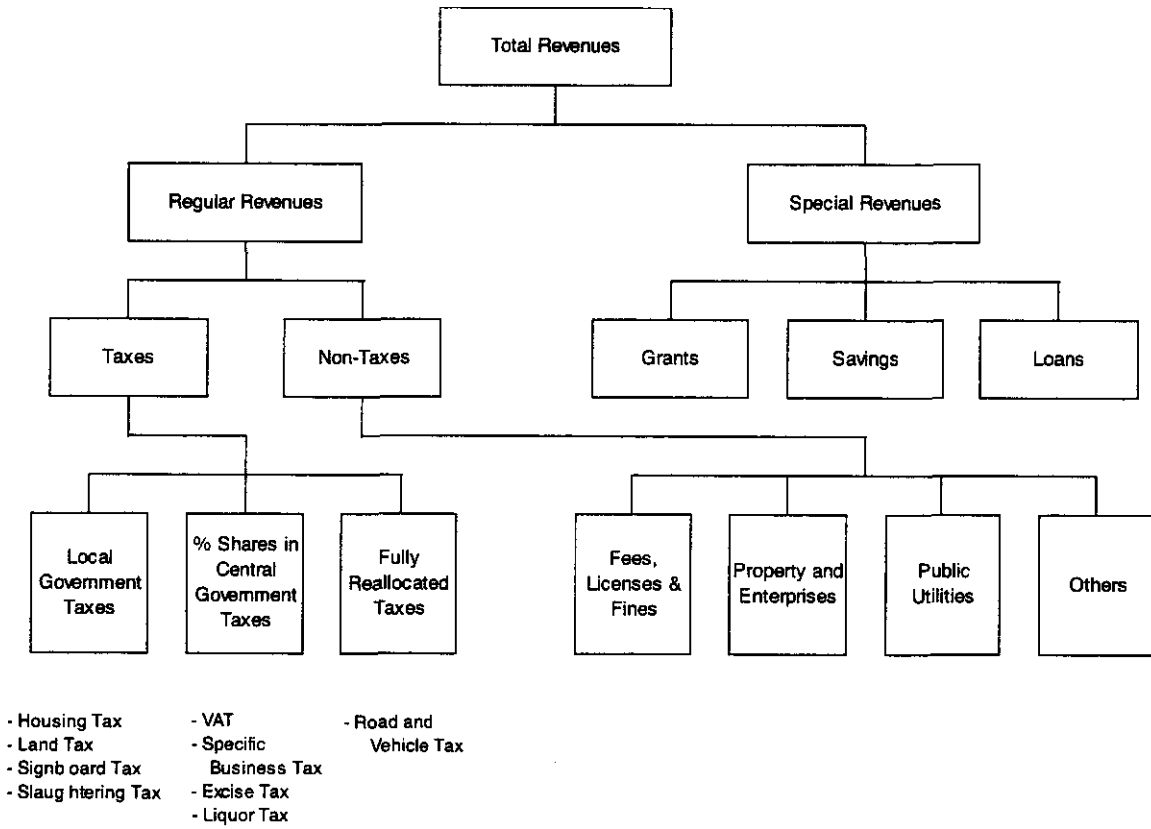
Category 2: Additions on central government taxes

By legislation local governments are entitled to collect an additional percentage on top of those tax categories collected by the central government. The following two main categories of these taxes are included:

- **Value added tax on goods and services:** the rates of which are determined by the central government. By law a local government may collect an additional value added tax up to a certain percentage on top of the rate determined by the central government. Currently the VAT is 10 percent. Local government's share is 1 percent, whereas 9 percent goes to the central government. The percentage of VAT is further distributed to all local governments proportionally: 60 percent is allocated to the BMA, 25.43 percent to the municipalities, 7.07 percent to the PAOs, 5.5 percent to the Sukhapiban and 2 percent to the TAOs.
- **Specific business taxes:** levied on certain businesses in the region. Rates, are determined by the central government. These include 3 percent of revenues on banking and financial business, 2.5 percent on life insurance, 3 percent on general insurance business and 2.5 percent on pawning. Local government may collect an additional percentage of not more than 10 percent of these rates, i.e. 0.3 percent. In practice, central government departments, taking 5 percent of local government's share as a service charge, undertake the actual collection of these taxes. Other taxes of this category include liquor tax, excise and gambling taxes.

Category 3: Road and vehicle taxes

Those taxes are collected by the Department of Land Transport which is a part of Ministry of Transport and Communication. The total amount of tax collected minus 5 percent service charge is fully allocated to local governments.



Source: ESCAP

Figure 2.1.5.2 Revenue Scheme of Local Government



2.2 Socio-economic Inputs for Year 2011 Inventories

This section describes how to produce socio-economic inputs for inventory database establishment on mobile and stationary sources. Due to data availability, both stationary and mobile have different approaches to produce the inputs.

As for mobile source inventory, traffic demand forecasts in every transport sector have been produced in the recent studies as described in Section 2.2.1 below. The growth rate of emissions was estimated based upon the demand forecasts of the studies.

While, except for a part of some sector energy demand forecast is not available. Therefore, the JICA Study Team established a methodology to formulate an energy demand forecast model, and furthermore calculated growth rate of energy consumption for each economic activity such as agriculture, industry and so forth.

2.2.1 Review of Socio-economic Frameworks for Related Studies

Many agencies and studies produce estimates of future growth of GDP and population. Such socio-economic frameworks at national and provincial (Changwat) level are used for future demand forecast such as traffic volume and energy consumption. The transport sector studies below also produced traffic demand forecasts using such socio-economic frameworks. In advance of using the traffic demand forecasts for inventory development it is necessary to ensure what kind of socio-economic frameworks are used. Therefore, the JICA Study Team reviewed and analyzed the socio-economic frameworks at national and regional level employed in those studies.

- (1) Consulting Services for the Study on the Strengthening of DOH's Management and Updating of the long-term Strategic Investment Plan, December 2001 (hereafter 'LTP-2')
- (2) Urban Rail Transportation Mater Plan (BMA and Surrounding Areas), November 2001 (hereafter 'URMAP')
- (3) The Study on Airport Development Master Plan in the Kingdom of Thailand, January 2000 (hereafter 'Airport Study')
- (4) The Master Plan Study for the Coastal Channels and Ports Development in the Kingdom of Thailand, March 2002 (hereafter 'Harbor Study')
- (5) Investment of Capacity Constraints and Determination of the Need for Track Doubling of SRT Network (2002) (hereafter 'TDSRT')



2.2.1.1 Population Projection

1) National Level

Table 2.2.1.1 summarizes population projections of the related studies above. As Figure 2.2.1.1 shows, each population projection that the related studies produced are almost similar to the NESDB's projection that has been prepared by the Human Resources Planning Division of the NESDB which takes into account fertility and mortality assumptions by region, and inter-region migration.

Table 2.2.1.1 Population Projections of the Related Studies and NESDB

Related Study	Projection period	N.B.
Airport Study	1996-2017	registered population basis
LTP-2	2001-2021	
URMAP	1996-2021	
NESDB	1999-2016	

Source: NESDB, LTP-2 and Airport Study and URMAP

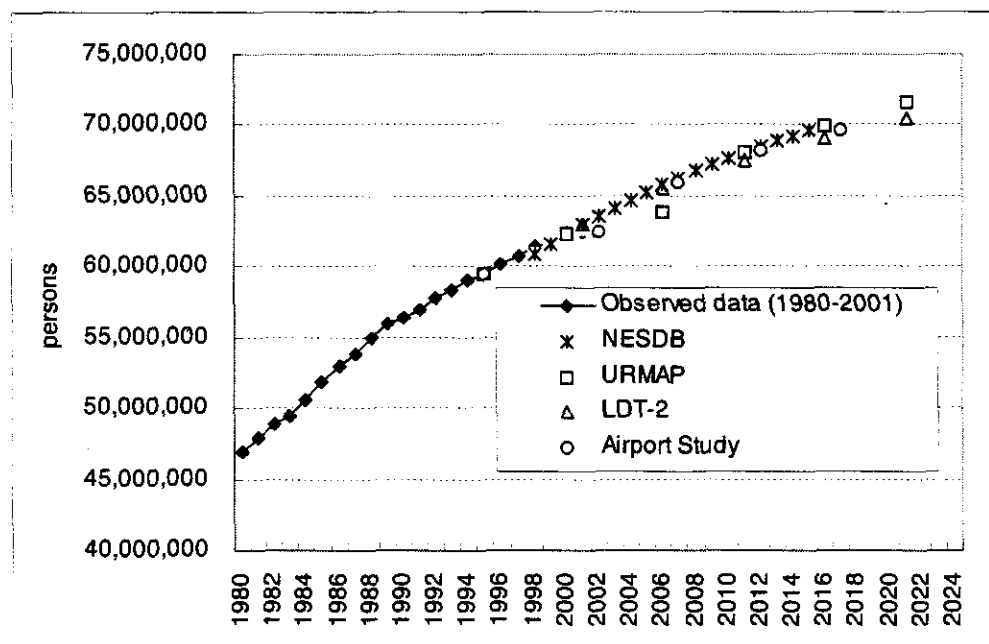


Figure 2.2.1.1 Comparisons of Population Projections of the Related Studies and NESDB

2) Regional and Provincial (Changwat) Level

The population projection of the Airport Study is on a provincial basis but the others' are on a regional basis. Table 2.2.1.2 summaries the projections of each study. In addition, Table 2.2.1.3 shows the regional projection produced by LTP-2.



As Figure 2.2.1.2 shows population projections for the BMR and the projections for both URMAP and LTP-2 are almost the same but the projection of the Airport Study is lower than those.

Table 2.2.1.2 Population Projections of the Related Studies at Regional Level

Study	Projection period	Projection level
Airport Study	1996-2016	Provincial (changwat) level
LTP-2	2001-2021	Regional level
URMAP	2000-2021	BMR including provincial level

Note: Adjusted population includes unregistered population

Table 2.2.1.3 Population Projections by Region (2002 – 2021)

Unit: 1,000 persons

Region/Country	Year	2001	2006	2011	2016	2021
BMR		11,574	12,774	13,708	14,562	15,392
Central Region		2,928	2,945	2,927	2,911	2,895
Eastern Region		4,025	4,226	4,423	4,557	4,681
Western Region		3,497	3,610	3,692	3,753	3,809
Northeastern Region		21,215	21,813	22,287	22,591	22,865
Northern Region		11,269	11,289	11,240	11,179	11,112
Southern Region		8,439	8,851	9,215	9,477	9,718
Whole Kingdom		62,947	65,508	67,492	69,030	70,472

Source: LTP-2

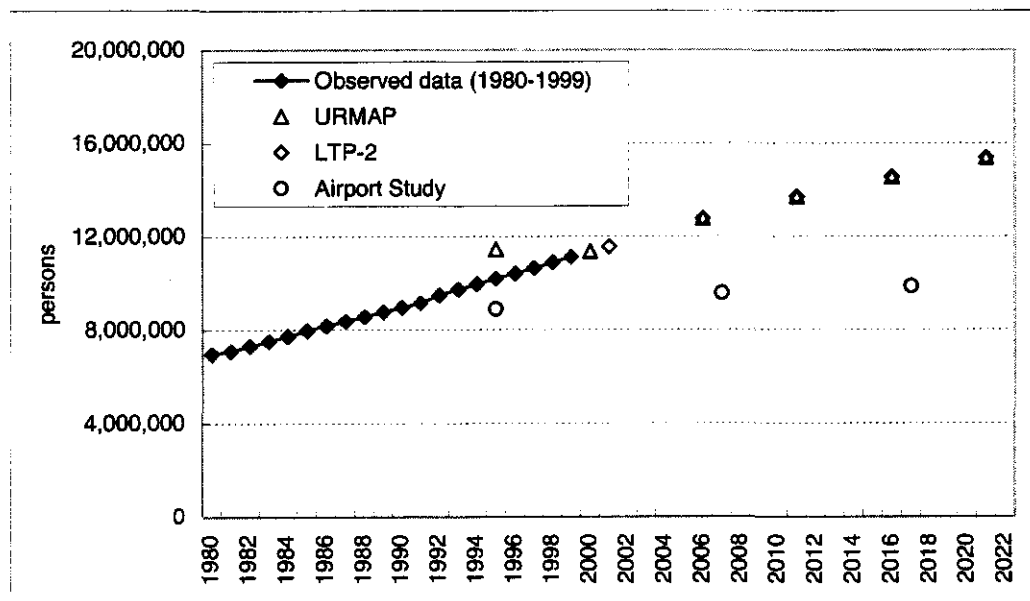


Figure 2.2.1.2 Population Projections for BMR



2.2.1.2 GDP Projections

1) National Level

Table 2.2.1.4 summarizes the GDP projections that the related studies produced. The Airport Study set out three scenarios (high, moderate and low) mainly due to the difficulty of identifying single estimate after the economic crisis in 1997. As Figure 2.2.1.3 shows, both the projections for LTP-2 and the moderate-case of the Airport Study are almost the same after 2014. The differentiation in 2011 is 459,420 bahts and is quite small.

Table 2.2.1.4 GDP Projections of the Related Studies

Study	Base year	GDP Growth Scenarios
Airport Study	1995	High (1996-2001: 3%, 2002-2017: 7%)
		Moderate (1996-2007: 4.5%, 2008-2017: 4%)
		Low (1996-2001: 0%, 2002-2017: 3%)
LTP-2	2001	2002-2006: 5.6%, 2007-2011: 5.7%, 2012-2016: 5.3%, 2017-2021: 5.2%

Source: LTP-2 and Airport Study

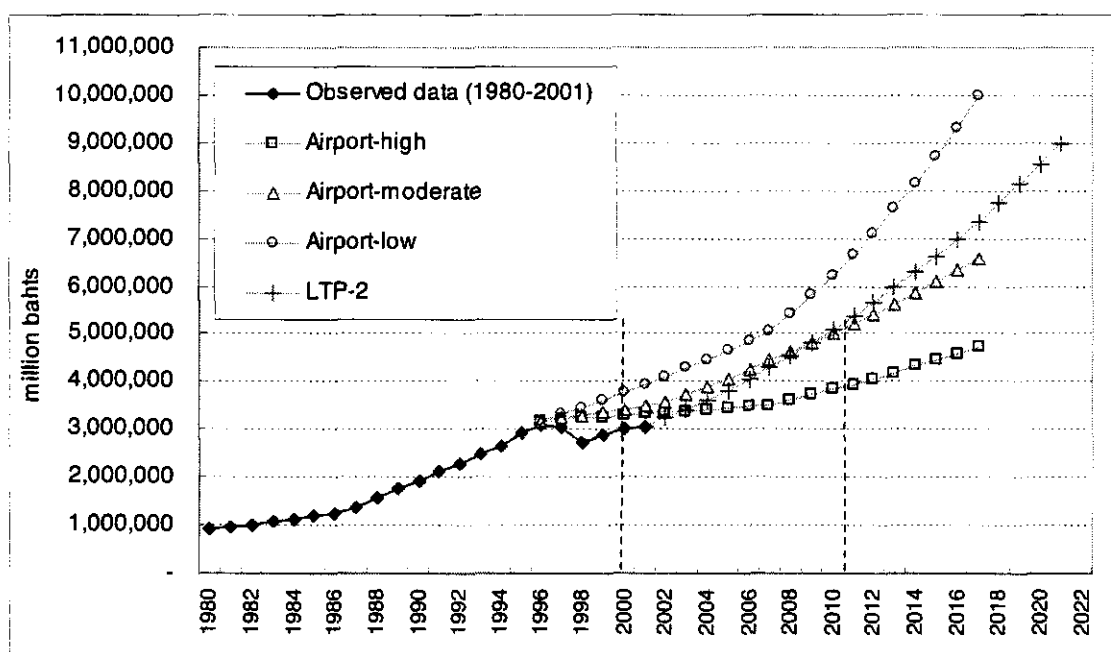


Figure 2.2.1.3 GDP Projections of the Related Studies

LTP-2 estimated the GDP projections by sector as shown in Table 2.2.1.5. The agricultural sector is projected to grow more slowly and achieve the level before the financial crisis in 1997, while both the manufacture and service sectors show a slow-down of growing speed during the period between 2002 and 2021 (refer to 2.2.1.5).



Table 2.2.1.5 GDP Projection by Sectors (% per annum)

Sector \ Year	2002-2006	2007-2011	2012-2016	2017-2021
Agriculture	2.1	2.3	2.5	2.9
Manufacture	6.5	6.4	6.1	6.0
Services	5.4	5.6	5.0	4.7
Total	5.6	5.7	5.3	5.2

Source: LTP-2 and TDRI

2) Regional and Provincial (Changwat) Level

LTP-2 and URMAP forecasts the future trends of GDP at regional basis. Those two are almost the same. Table 2.2.1.6 shows the example of the regional forecast for LTP-2. These show broadly similar growth throughout the whole kingdom, but with lower rates in the Northeastern, Northern and Southern regions than in the BMR. In the long term, the Eastern region is expected to show the largest growth in GRP. Table 2.2.1.7 summaries the GDP projections of the related studies for BMR. As Figure 2.2.1.4 shows, the GDP projections for BMR, and the optimistic scenario of the Harbor Study, URMAP and LTP-2 are almost the same.

Table 2.2.1.6 GDP Projections for Regions by LTP-2 (% per annum)

Region \ Year	2002-2006	2007-2011	2012-2016	2017-2021
BMR	5.8	5.8	5.4	5.2
Central	5.6	5.9	5.2	4.8
Eastern	5.7	6.0	6.4	6.9
Western	5.5	5.8	5.8	5.0
Northeastern	4.9	5.1	5.1	4.9
Northern	5.0	5.2	5.2	4.5
Southern	4.8	5.1	5.1	4.6
Whole Kingdom	5.6	5.7	5.3	5.2

Source: LTP-2 and TDRI



Table 2.2.1.7 GDP Projections of the Related Studies for BMR

Study	Base year	GDP Growth Scenarios
Airport Study	1995	Project from 1996 to 2017 by province
Harbor Study	1995	Optimistic (1996-2000: 0.2%, 2001-2006: 5.5%, 2007-2011: 5.2%, 2012-2016: 5.4)
		Base (1996-2000: 2.8%, 2001-2006: 4.2%, 2007-2011: 4.2%, 2012-2016: 4.4)
		Pessimistic (1996-2000: 0.0%, 2001-2006: 3.2%, 2007-2011: 3.2%, 2012-2016: 3.5%)
LTP-2	2001	2002-2006: 5.8%, 2007-2011: 5.8%, 2012-2016: 5.4%, 2017-2021: 5.2%
URMAP	1995	1996-1999: -0.60%, 2000-2006: 5.16%, 2007-2011: 6.0%, 2012-2016: 5.2%, 2017-2021: 5.0%

Source: LTP-2, URMAP, Airport Study and Harbor Study

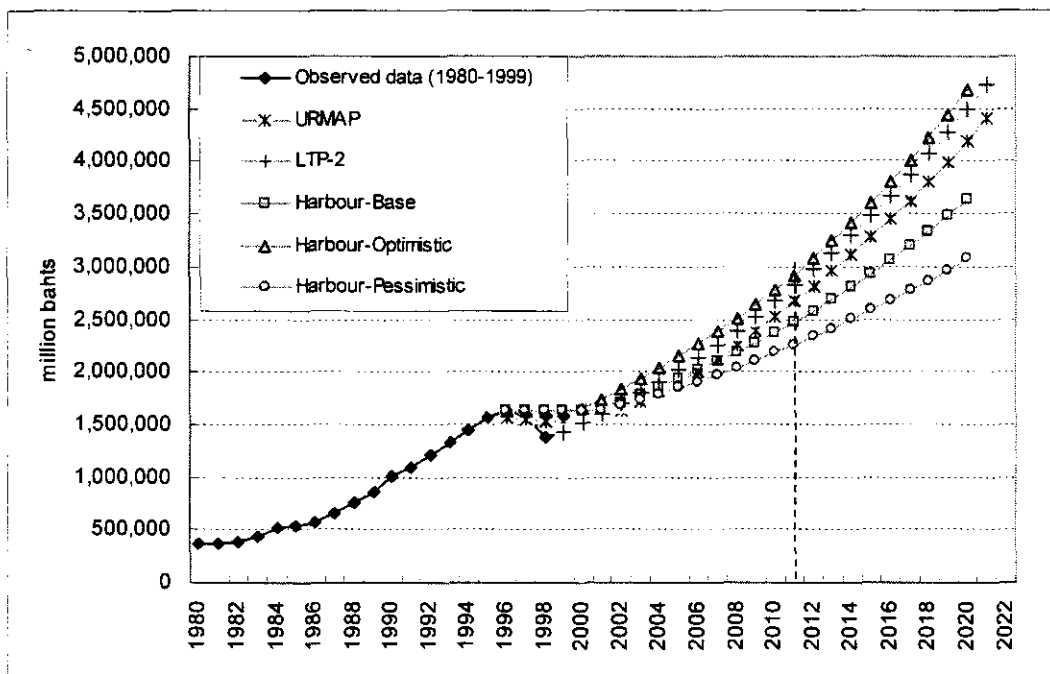


Figure 2.2.1.4 GDP Projections of the Related Studies for BMR



2.2.2 Socio-economic Inputs for Stationary Source Inventory

2.2.2.1 Targeted economic sector and Type of source

As Table 2.2.2.1 shows this analysis included overall economic sectors, but electricity sector and a part of manufacture industries that energy demand forecasts had been estimated by environmental impact assessments were excluded in this analysis (refer to Chapter 3).

Table 2.2.2.1 Targeted Sectors and Type of Source

Economic sector \ Type of source	Point	Quasi-point Source	Area
Agriculture			X
Mining			X
Manufacture	X	X	X
Construction			X
Residential and Commerce			X

2.2.2.2 Energy Demand Forecast

1) Concept of GDP Elasticity Model for Demand Forecast

As Figure 2.2.2.1 shows, GDP and energy consumption had a good correlation each other. Because of such relationship, a GDP elasticity model consisting of economic and energy-related parameters is commonly used for energy demand forecast.

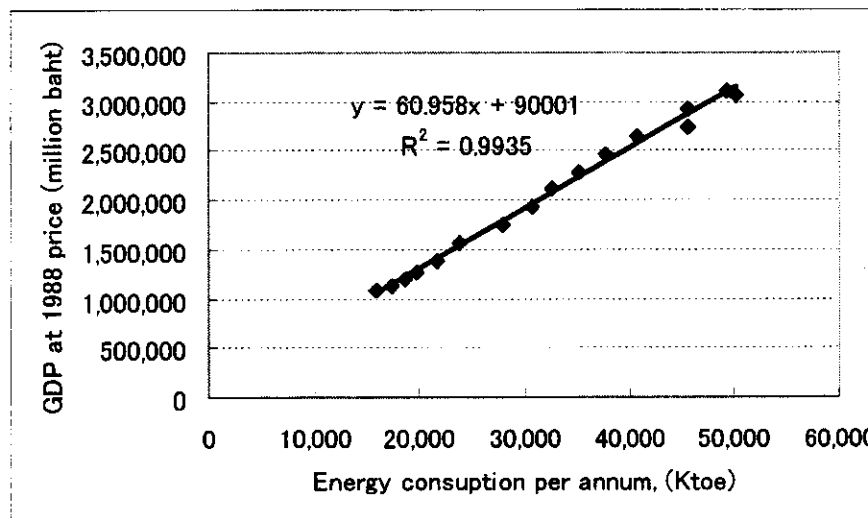


Figure 2.2.2.1 Correlation between GDP and Final Energy Consumption in the Whole Kingdom (1983-1999)



However, because of data availability, the model concept consisting of only GDP, which had a good correlation with energy demand as shown in Figure 2.2.2.1, was applied for modeling. Therefore, a statistical model that consisted of GDP elasticity, energy consumption and GDP was made as shown below.

$$Ec_{t+1} = EI \times \Delta GDP \times Ec_t \quad (2.2.2.1)$$

t: year 2000-2011

EI: elasticity coefficient ($\Delta Ec / \Delta GDP$)

Ec: energy consumption

2.2.2.3 Concept of GDP Elasticity Model considering Sectoral Economic Activities

Mainly because of various economic development activities and population migrations in each region, it is necessary to clear regional disparities of emission impacts considering amount and quality of discharged emissions from stationary sources reflected by plausible economic development and structure in each region. Therefore, the Formula 2.2.2.2 was modified into regional and sectoral basis as below.

$$SEc_{t+1} = SEI \times \Delta SGrp \times SEc_t \quad (2.2.2.2)$$

t: year 2000-2011

SEc: Sectoral energy consumption

SEI: GDP elasticity for each economic sector

$\Delta SGrp$: growth rate of sectoral GRP

2.2.2.4 Sectoral GRP Projections

1) Economic Growth Scenarios by Sector

Regarding GDP projections, especially for the long-term ones, only TDRI provided the GDP projections including regional and sectoral breakdown (refer to Table 2.2.2.2 and Table 2.2.2.3). Therefore, a trend analysis that considers each region's sectoral activities was employed in this study. For instance, using the time serial data on the sectoral GRP (1985 - 1996) of each region, the average growth rates were calculated and were used as their future economic growth scenarios.

2) Justification to Sectoral GRP Projections

Estimated values of Gross Regional Products (hereafter, GRP) based upon the above-mentioned approach were over or under the regional scenarios that the TDR I produced. In order to adjust the estimated sectoral GRP to the both projections of sectoral GDP (Table 2.2.2.2) and GRP (Table 2.2.2.3), a control factor was employed as shown in the Formula 2.2.2.3.

Table 2.2.2.2 GDP Projection by Sectors (% per annum)

Sector \ Year	2002-2006	2007-2011	2012-2016	2017-2021
Agriculture	2.1	2.3	2.5	2.9
Manufacture	6.5	6.4	6.1	6.0
Services	5.4	5.6	5.0	4.7
Total	5.6	5.7	5.3	5.2

Source: LTP-2 and TDR I

Table 2.2.2.3 GDP Projections by Regions (% per annum)

Region \ Year	2002-2006	2007-2011	2012-2016	2017-2021
BMR	5.8	5.8	5.4	5.2
Central Region	5.6	5.9	5.2	4.8
Eastern Region	5.7	6.0	6.4	6.9
Western Region	5.5	5.8	5.8	5.0
Northeastern Region	4.9	5.1	5.1	4.9
Northern Region	5.0	5.2	5.2	4.5
Southern Region	4.8	5.1	5.1	4.6
Whole Kingdom	5.6	5.7	5.3	5.2

Source: LTP-2 and TDR I

3) GRP Forecast Model

A GRP forecast model established in this study is describes as below. In addition, Table 2.2.2.4 and Figure 2.2.2.2 shows the projection at regional level and national level respectively.

$$SGrp_{t+1} = Avg \times Cf \times SGrp_t \quad (2.2.2.3)$$

t: year 2000-2011

SGrp: sectoral GRP (Gross Regional Products)

Avg: average growth rate of sectoral GRP (from 1989 to 1996)

Cf: Grp (TDR I's projection) / Σ SGrp

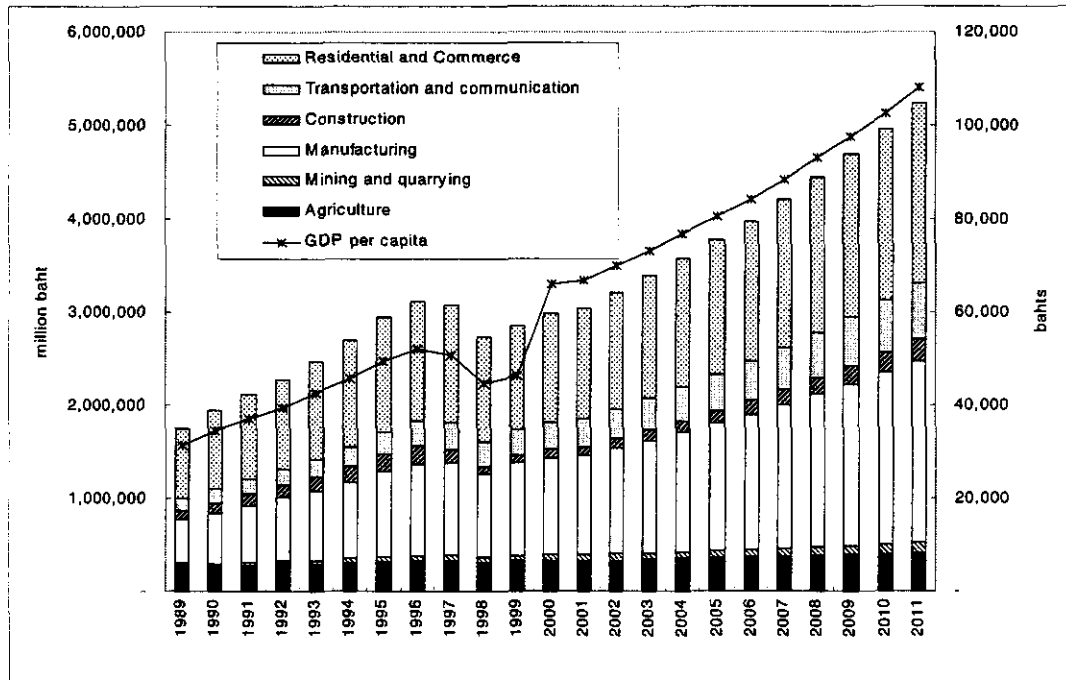


Figure 2.2.2.2 GDP Projections by Sector

2.2.2.5 Energy Consumption Forecast by GDP Elasticity Model

1) Formula of GDP Elasticity Model

The GDP elasticity model was finalised, incorporating the above GRP projection model and consists of sectoral elasticity and GRP growth.

$$SE_{t+1} = SEI \times \Delta SGrp \times SE_t \tag{2.2.2.5}$$

t: year 2000-2011

SEI: sectoral elasticity ($\Delta SEg / \Delta SGdp$)

$\Delta SGrp$: growth rate of SGRP adjusted by control factors (refer to Formula 2.2.3.3)

2) GDP Elasticity

In order to estimate elasticity coefficient for each economic factor, final energy consumption and GDP data at national level were used.

Elasticity value is generally influenced by economic level of country (refer to BOX 4). Judging from the available data (1986 - 1999), the economic growth before 1989 was relatively slower than that after the year. Also, the data after 1997 was strongly influenced by the economic crisis and

BOX 4

GDP Elasticity
 =growth rate of Final energy consumption /GDP growth rate

Elasticity= 1 unit energy consumption same
 Elasticity> 1 unit energy consumption increases
 Elasticity< 1 unit energy consumption decreases

Elasticity < 1 means continuous increase of energy productivity according to economic development such as innovation of energy saving, industrial reformation and consumption structure etc.

showed unstable economic growth. Considering such economic situations, only the data between 1989 and 1996 were used for the analysis of GDP elasticity as representatives. Table 2.2.2.5 summarizes the estimated GDP elasticity coefficients by economic sector.

Table 2.2.2.5 GDP Elasticity Coefficient by Sector (1989-1996)

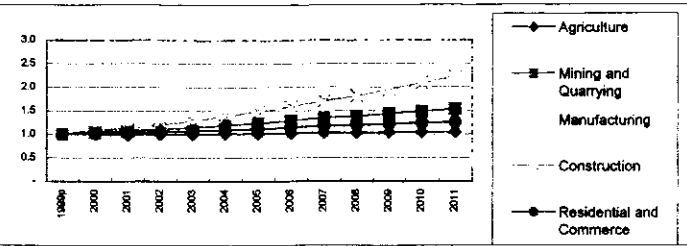
Economic Sectors	Elasticity Coefficient
Agriculture	0.938
Mining and quarrying	0.379
Manufacturing	0.906
Construction	1.021
Residential and Commerce	0.508

Source: JICA Study Team analyzed

Table 2.2.2.6 Energy Consumption Projections by Region and Sector

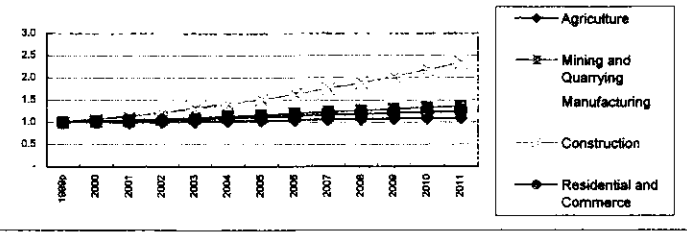
NORTHEASTERN

Economic and Social Development Plan	Eighth Plan			Ninth Plan				Tenth Plan					Growth Rate 2011/2000	
Year	1999p	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010		2011
Economic Sectors														
Agriculture	1.00	1.01	0.99	0.99	1.00	1.01	1.01	1.02	1.03	1.03	1.04	1.04	1.05	1.04
Mining and Quarrying	1.00	1.04	1.07	1.11	1.15	1.19	1.24	1.28	1.33	1.38	1.43	1.48	1.54	1.48
Manufacturing	1.00	1.08	1.15	1.25	1.35	1.47	1.59	1.72	1.86	2.01	2.17	2.35	2.53	2.33
Construction	1.00	1.07	1.12	1.20	1.29	1.38	1.48	1.58	1.69	1.81	1.94	2.08	2.22	2.07
Residential and Commerce	1.00	1.02	1.03	1.05	1.07	1.09	1.12	1.14	1.16	1.19	1.21	1.24	1.26	1.23



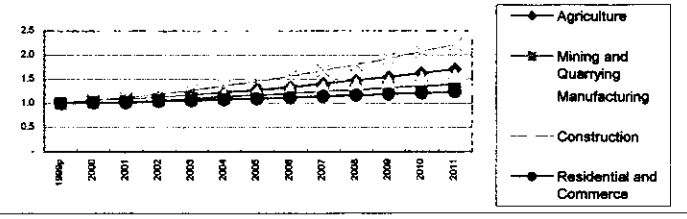
NORTHERN

Year	1999p	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Growth Rate 2011/2000
Economic Sectors														
Agriculture	1.00	1.01	0.99	1.00	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.08
Mining and Quarrying	1.00	1.03	1.04	1.07	1.10	1.13	1.16	1.19	1.22	1.25	1.29	1.32	1.36	1.32
Manufacturing	1.00	1.08	1.14	1.24	1.34	1.46	1.58	1.71	1.85	1.99	2.15	2.32	2.50	2.31
Construction	1.00	1.08	1.12	1.21	1.31	1.40	1.51	1.62	1.75	1.88	2.02	2.17	2.33	2.17
Residential and Commerce	1.00	1.02	1.02	1.05	1.07	1.09	1.11	1.13	1.15	1.18	1.20	1.22	1.25	1.22



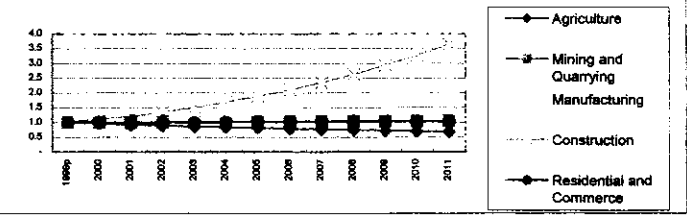
SOUTHERN

Year	1999p	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Growth Rate 2011/2000
Economic Sectors														
Agriculture	1.00	1.05	1.07	1.12	1.17	1.22	1.28	1.34	1.40	1.47	1.54	1.62	1.70	1.62
Mining and Quarrying	1.00	1.03	1.05	1.08	1.11	1.14	1.17	1.20	1.24	1.28	1.31	1.35	1.39	1.35
Manufacturing	1.00	1.04	1.05	1.10	1.14	1.19	1.24	1.29	1.34	1.39	1.45	1.51	1.57	1.51
Construction	1.00	1.07	1.11	1.19	1.27	1.36	1.46	1.56	1.67	1.79	1.92	2.06	2.21	2.07
Residential and Commerce	1.00	1.02	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.21	1.23	1.21



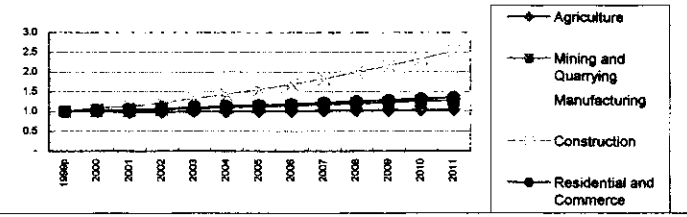
EASTERN

Year	1999p	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Growth Rate 2011/2000
Economic Sectors														
Agriculture	1.00	0.97	0.91	0.88	0.86	0.83	0.81	0.78	0.76	0.74	0.72	0.69	0.67	0.70
Mining and Quarrying	1.00	1.00	1.00	1.00	1.01	1.01	1.02	1.02	1.03	1.03	1.04	1.04	1.05	1.04
Manufacturing	1.00	1.07	1.11	1.20	1.28	1.38	1.48	1.58	1.69	1.81	1.94	2.07	2.21	2.07
Construction	1.00	1.11	1.20	1.35	1.51	1.68	1.88	2.10	2.34	2.62	2.93	3.27	3.64	3.27
Residential and Commerce	1.00	1.00	0.99	0.99	1.00	1.00	1.00	1.01	1.01	1.01	1.02	1.02	1.02	1.02



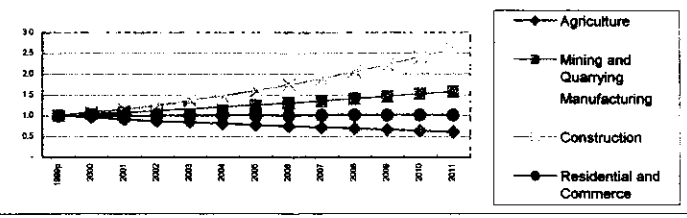
WESTERN

Year	1999p	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Growth Rate 2011/2000
Economic Sectors														
Agriculture	1.00	1.00	0.98	0.98	0.99	1.00	1.00	1.01	1.01	1.02	1.03	1.03	1.04	1.04
Mining and Quarrying	1.00	1.02	1.03	1.05	1.07	1.10	1.12	1.14	1.17	1.20	1.22	1.25	1.28	1.25
Manufacturing	1.00	1.07	1.12	1.21	1.30	1.40	1.51	1.63	1.75	1.89	2.03	2.18	2.34	2.18
Construction	1.00	1.08	1.13	1.22	1.33	1.44	1.56	1.68	1.83	1.98	2.15	2.33	2.52	2.34
Residential and Commerce	1.00	1.02	1.03	1.06	1.09	1.12	1.15	1.18	1.21	1.25	1.28	1.32	1.35	1.32



CENTRAL

Year	1999p	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Growth Rate 2011/2000
Economic Sectors														
Agriculture	1.00	0.96	0.90	0.87	0.84	0.81	0.77	0.74	0.71	0.69	0.66	0.63	0.60	0.63
Mining and Quarrying	1.00	1.04	1.07	1.11	1.16	1.21	1.25	1.30	1.35	1.41	1.46	1.52	1.57	1.51
Manufacturing	1.00	1.08	1.14	1.23	1.34	1.44	1.56	1.68	1.81	1.95	2.09	2.25	2.41	2.23
Construction	1.00	1.09	1.14	1.25	1.36	1.48	1.61	1.74	1.89	2.05	2.22	2.40	2.59	2.39
Residential and Commerce	1.00	1.00	0.99	1.00	1.00	1.00	1.01	1.01	1.01	1.01	1.02	1.02	1.02	1.01



BANGKOK AND VICINITIES

Year	1999p	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Growth Rate 2011/2000
Economic Sectors														
Agriculture	1.00	1.01	1.00	1.03	1.05	1.08	1.11	1.13	1.16	1.19	1.22	1.25	1.28	1.26
Mining and Quarrying	1.00	1.04	1.07	1.11	1.16	1.21	1.26	1.31	1.36	1.42	1.48	1.55	1.61	1.55
Manufacturing	1.00	1.03	1.04	1.08	1.13	1.17	1.22	1.27	1.32	1.38	1.43	1.48	1.54	1.49
Construction	1.00	1.09	1.16	1.29	1.42	1.57	1.74	1.92	2.13	2.35	2.60	2.88	3.18	2.91
Residential and Commerce	1.00	1.03	1.04	1.07	1.10	1.14	1.17	1.21	1.25	1.29	1.33	1.37	1.41	1.38

