社会開発調査部報告書

THE MASTER PLAN STUDY
ON
LAND USE AND SUBSTITUTING CROPS
WATER RESOURCES DEVELOPMENT

FINAL REPORT
VOLUME II
MAIN REPORT

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE SOCIALIST REPUBLIC OF VIET NAM
MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT

THE MASTER PLAN STUDY
ON
DONG NAI RIVER AND SURROUNDING BASINS
WATER RESOURCES DEVELOPMENT

FINAL REPORT

VOLUME II

MAIN REPORT

AUGUST 1996

NIPPON KOEI CO., LTD., TOKYO JAPAN

This Report consists of

Volume I	Executive Summary	
Volume II	Main Report	
Volume III	Appendix I	Socio-economy and Institution
Volume IV	Appendix II	Topography and Geology
	Appendix III	Meteorology and Hydrology
Volume V	Appendix IV	Natural Environment
Volume VI	Appendix V	Hydropower Generation
Volume VII	Appendix VI	Agricultural Development and Irrigation
Volume VIII	Appendix VII	Domestic and Industrial Water Supply
Volume IX	Appendix VIII	Flood Mitigation and Urban Drainage
	Appendix IX	Salinity Intrusion
Volume X	Appendix X	Formulation of Master Plan
Volume XI	Data Book	

The cost estimate was based on the December 1995 price level and expressed in US$ according to the exchange rate of US$ 1.00 = Vietnamese Dong 11,014 = Japanese Yen 101.53 as of December 15, 1995.

PREFACE

In response to a request from the Government of the Socialist Republic of Viet Nam, the Government of Japan decided to conduct a master plan study on Dong Nai River and Surrounding Basins Water Resources Development and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Viet Nam a study team headed by Mr. Masashi Yamaguchi Nippon Koei Co., Ltd., (four times between September 1994 and May 1996).

The team held discussions with the officials concerned of the Government of Viet Nam, and conducted field surveys at the study area. 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 project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Socialist Republic of Viet Nam for their close cooperation extended to the team.

August, 1996

Kimio Fujita
President
Japan International Cooperation Agency

August 1996

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

Dear Sir,

Letter of Transmittal

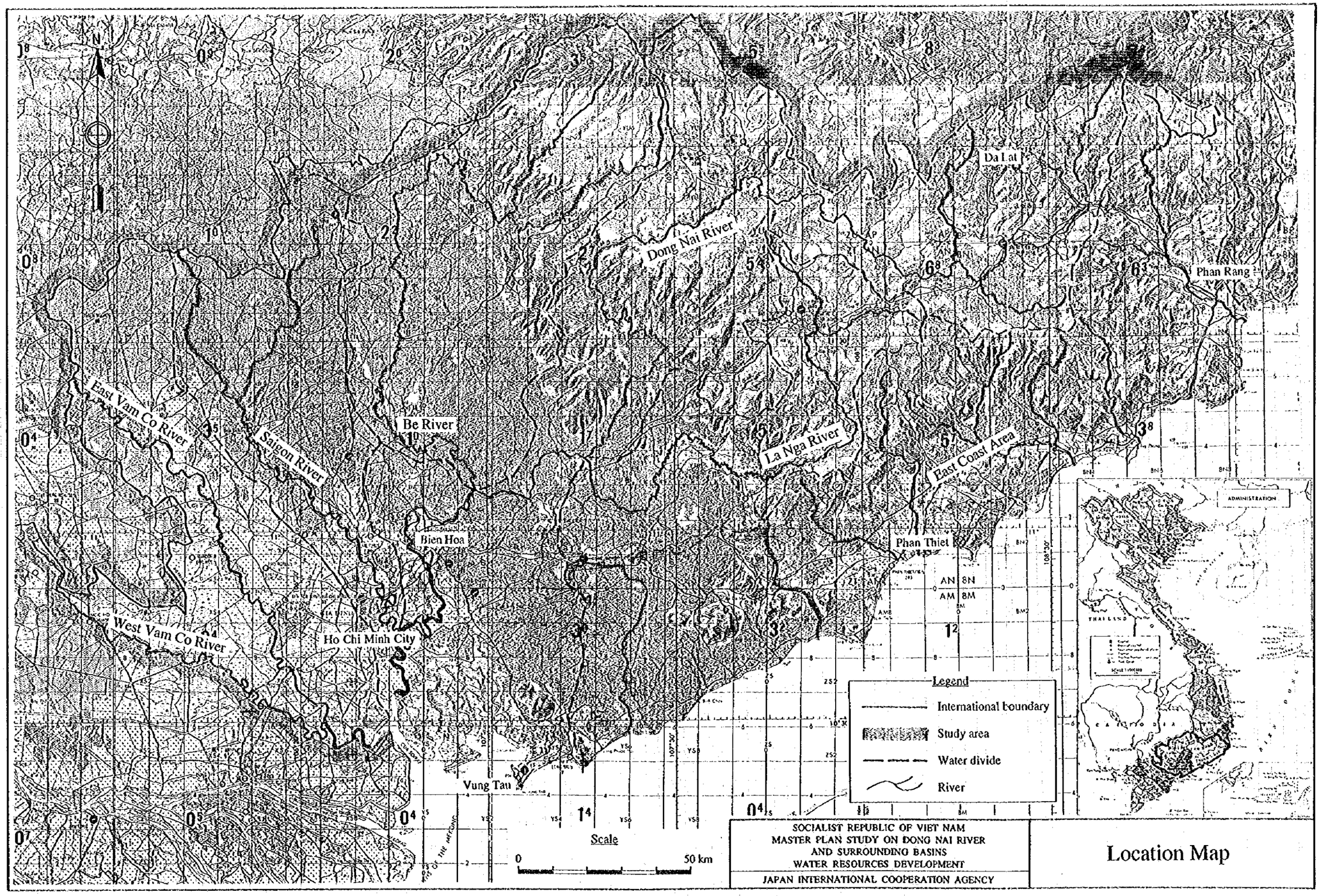
We are pleased to submit herewith the Final Report of the Master Plan Study on Dong Nai River and Surrounding Basins Water Resources Development. This Report deals with the formulation of master plan for water resources development in the Dong Nai River and its surrounding river basins. Studies were further extended to the master plan projects selected in this study taking into consideration not only economic viability but also contribution to the regional development and spatial distribution.

The Report consists of 11 volumes; Volume I for Executive Summary, Volume II for Main Report, Volumes III to X for Appendixes and Volume XI for Data Book. Main outputs of this study are presented in Executive Summary. The Main Report deals with the general study of the master plan including the preliminary discussions for the master plan projects selected in this study as well as the selection of priority projects to proceed to the further detailed study stage. Appendixes give in-depth discussions for respective study items. Data Book compiles the result of land use analysis by landsat image, hydrological records and the result of topographic survey.

We would like to express our grateful acknowledgment to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Construction, and Embassy of Japan in Viet Nam, and also to officials and individuals of the Government of Viet Nam for their assistance and advice extended to the Study Team. We sincerely hope that the results of this study would contribute to the regional development of the Study Area.

Your sincerely,

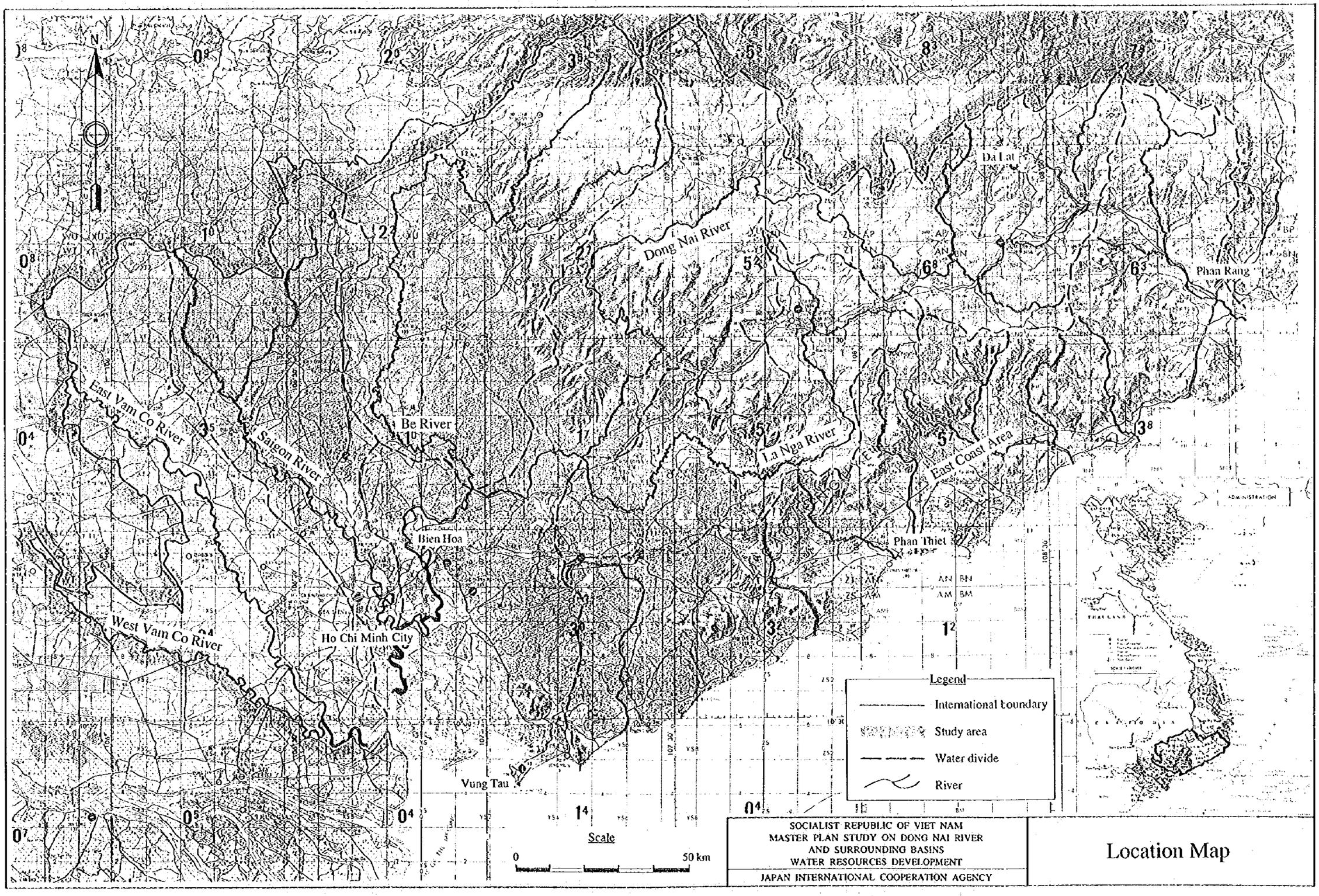
Masashi Yamaguchi
Team Leader
The Master Plan Study on
Dong Nai River and Surrounding Basins
Water Resources Development



SOCIALIST REPUBLIC OF VIET NAM
MASTER PLAN STUDY ON DONG NAI RIVER
AND SURROUNDING BASINS
WATER RESOURCES DEVELOPMENT

JAPAN INTERNATIONAL COOPERATION AGENCY

Location Map



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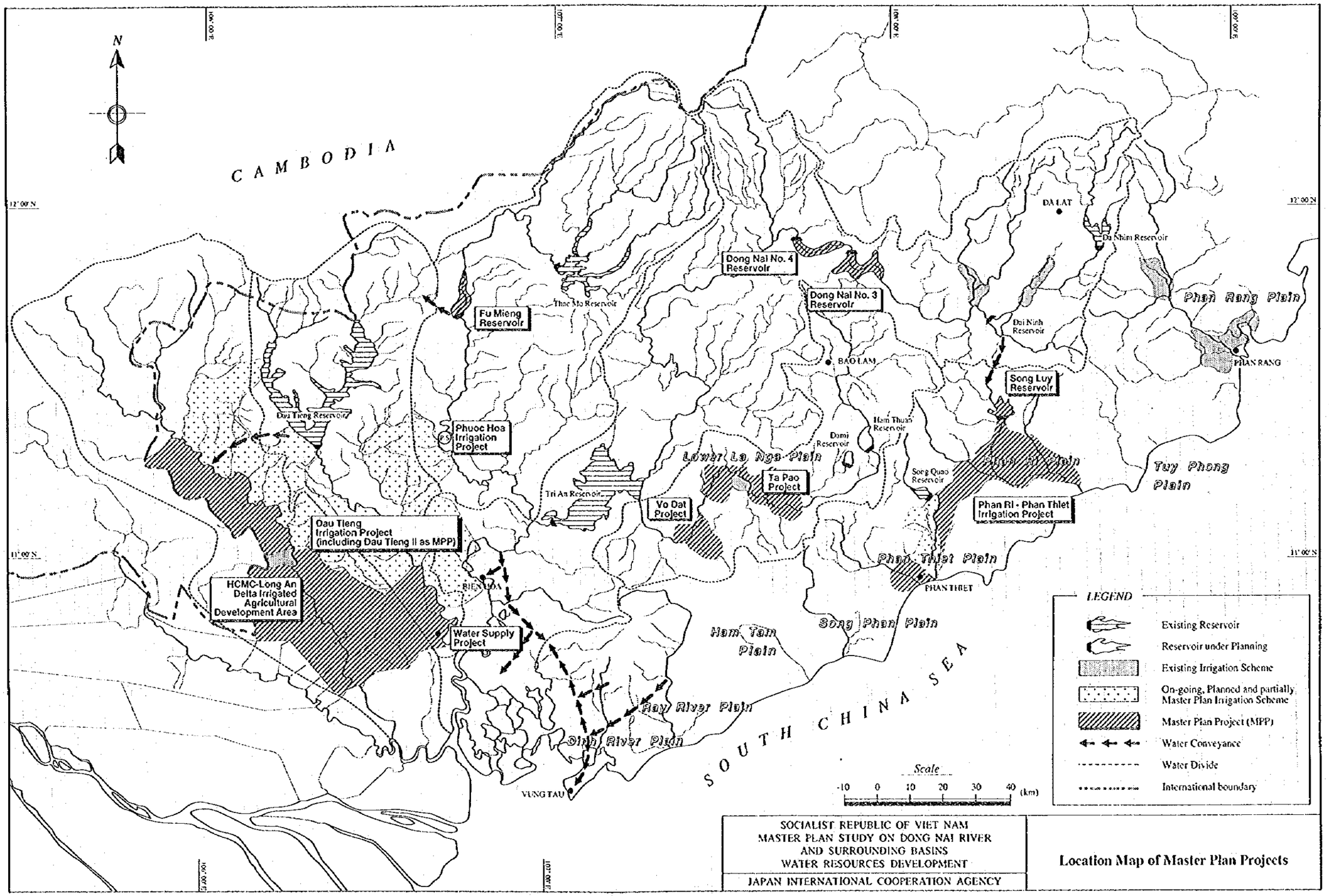
N
CAMBODIA
12°00'N
DA LAT
Da Nhim Reservoir
Dong Nai No. 4 Reservoir
Dong Nai No. 3 Reservoir
Thac Mo Reservoir
Fu Mieng Reservoir
Phan Rang Plain
Dai Ninh Reservoir
PHAN RANG
BAO LAM
Song Luy Reservoir
Dau Tieng Reservoir
Phuoc Hoa Irrigation Project
Ham Thuan Reservoir
Dami Reservoir
Lower La Nga Plain
Ta Pao Project
Song Quao Reservoir
Phan Ri - Phan Thiet Irrigation Project
Tuy Phong Plain
Tri An Reservoir
Vo Dat Project
Dau Tieng Irrigation Project (including Dau Tieng II as MPP)
Phan Thiet Plain
PHAN THIET
11°00'N
HCMC-Long An Delta Irrigated Agricultural Development Area
BIEN HOA
Water Supply Project
Ham Tan Plain
Song Phan Plain
SOUTH CHINA SEA
Thay River Plain
Dinh River Plain
VUNG TAU
LEGEND
Existing Reservoir
Reservoir under Planning
Existing Irrigation Scheme
On-going, Planned and partially Master Plan Irrigation Scheme
Master Plan Project (MPP)
Water Conveyance
Water Divide
International boundary
Scale
-10 0 10 20 30 40 (km)
SOCIALIST REPUBLIC OF VIET NAM
MASTER PLAN STUDY ON DONG NAI RIVER AND SURROUNDING BASINS WATER RESOURCES DEVELOPMENT
JAPAN INTERNATIONAL COOPERATION AGENCY
Location Map of Master Plan Projects

MASTER PLAN STUDY
ON
DONG NAI RIVER AND SURROUNDING BASINS
WATER RESOURCES DEVELOPMENT

FINAL REPORT
Volume II MAIN REPORT

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LIST OF ABBREVIATIONS

AFS	Agriculture and Forestry Service (PC)
CEMMA	Committee for Ethnic Minorities and Mountainous Areas
DCWSSS	Design Company for Water Supply and Sanitation System (HCMC-PC)
EA	Environment Assessment (Multi-lateral Lending Agencies)
ECSP	Evaluation Commission for State Projects
EIA	Environmental Impact Assessment
ENCO	Hồ Chí Minh City Environmental Committee
EVN	*General Company of Electricity of Viet Nam (Abolished and renamed in November 1995 as Vietnamese Power Corporation)*
FIPI	Forest Inventory and Planning Institute (MOARD)
GCOP	Governmental Committee on Organization and Personnel
GDLA	General Department of Land Administration
GDMH	General Department of Meteorology & Hydrology
GOV	Government of Viet Nam
GSO	General Statistical Office
HCMC	Ho Chi Minh City
HEC	Ho Chi Minh Environment Committee (HCMC)
HIDC	Hydraulic Investigation and Design Company (MOARD)
HPC	Ho Chi Minh People's Committee (HCMC)
HSDC (or SDC)	Ho Chi Minh Sewerage and Drainage Company (HCMC)
HWSC (or WSC)	Ho Chi Minh Water Sypply Company (HCMC)
IDD	Irrigation and Drainage Department (MOARD)
IEE	Initial Environmental Examination
IER	Institute for Economic Research (HCMC-PC)
IHPH	Institute of Hygiene and Public Health (MOPH)
IM	Institute of Mines (MOID)
INVESCo	Investment Company for the Development of Water Sector (HCMC-PC/TUPWS)
IOE	Institute of Energy (MOID)
IURP	Institute of Urban and Rural Planning (HCMC-PC/Construction Service)
IWRE	Institute of Water Resources Economics (MOARD)
IWRP	Institute of Water Resources Planning (MOARD)
IWRR	Institute of Water Resources Research (MOARD)
JICA	Japan International Cooperation Agency (Japan)

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ECSP	Evaluation Commission for State Projects
EIA	Environmental Impact Assessment
ENCO	Ho Chi Minh City Environmental Committee
EVN	*General Company of Electricity of Viet Nam (Abolished and renamed in November 1995 as Vietnamese Power Corporation)*
FIPI	Forest Inventory and Planning Institute (MOARD)
GCOP	Governmental Committee on Organization and Personnel
GDLA	General Department of Land Administration
GDMH	General Department of Meteorology & Hydrology
GOV	Government of Viet Nam
GSO	General Statistical Office
HCMC	Ho Chi Minh City
HEC	Ho Chi Minh Environment Committee (HCMC)
HIDC	Hydraulic Investigation and Design Company (MOARD)
HPC	Ho Chi Minh People's Committee (HCMC)
HSDC (or SDC)	Ho Chi Minh Sewerage and Drainage Company (HCMC)
HWSC (or WSC)	Ho Chi Minh Water Sypply Company (HCMC)
IDD	Irrigation and Drainage Department (MOARD)
IEE	Initial Environmental Examination
IER	Institute for Economic Research (HCMC-PC)
IHPH	Institute of Hygiene and Public Health (MOPH)
IM	Institute of Mines (MOID)
INVESCo	Investment Company for the Development of Water Sector (HCMC-PC/TUPWS)
IOE	Institute of Energy (MOID)
IURP	Institute of Urban and Rural Planning (HCMC-PC/Construction Service)
IWRE	Institute of Water Resources Economics (MOARD)
IWRP	Institute of Water Resources Planning (MOARD)
IWRR	Institute of Water Resources Research (MOARD)
JICA	Japan International Cooperation Agency (Japan)

MOAFI	*Ministry of Agriculture and Food Industry (Abolished and integrated into the new MOARD)*
MOAP	Ministry of Aquatic Products
MOARD (New)	Ministry of Agriculture and Rural Development (Created in October 1995 by the merger of the former Ministry of Water Resources, Ministry of Agriculture and Food Industry and Ministry of Forestry)
MOC	Ministry of Construction
MOCI	Ministry of Culture and Information
MOD	Ministry of Defence
MOE	*Ministry of Energy (Abolished and integrated into the new MOID)*
MOET	Ministry of Education and Training
MOFI	Ministry of Finance
MOFO	*Ministry of Forestry (Abolished and integrated into the new MOARD)*
MOFA	Ministry of Foreign Affairs
MOHI	*Ministry of Heavy Industry (Abolished and integrated into the new MOID)*
MOID(New)	Ministry of Industry (Created in November 1995 by the merger of the former Ministries of Heavy Industry, Light Industry and Energy)
MOJ	Ministry of Justice
MOIT	Ministry of Interior
MOLI	*Ministry of Light Industry (Abolished and integrated into the new MOID)*
MOLWISA	Ministry of Labour, War Invalids and Social Affairs
MOPH	Ministry of Public Health
MOPI (New)	Ministy of Planning and Investment (Formed from a merger of the former SPC amd SCCI)
MOSTE	Ministry of Science, Technology and Environment
MOTC	Ministry of Transport and Communications
MOT	Ministry of Trade
MOWR	*Ministry of Water Resources (Abolished and integrated into the new MOARD)*
MPAC	Ministrial Project Appraisal Committee
NEA	National Environment Agency
NGO	Non-Governmental Organization
NIAPP	National Institute for Agricultural Planning and Projection
NPAC	National Project Appraisal Committee
OECC	Overseas Environmental Cooperation Centre
OECF	Overseas Economic Cooperation Fund (Japan)
PC	People's Committee (executive arm of the People's Council)

PCC	Power Construction Company (VPC)
PIDC	Power Investigation and Design Company (VPC)
PPC	Provincial People's Committee (City People's Committee = CPC)
SBV	State Bank of Viet Nam
SCCI	*State Committee for Cooperation and Investment (Abolished and integrated into the new MOPI)*
SFEZ (or SFEA)	Southern Focal Economic Zone (or Southern Focal Economic Area)
SIWRP	Sub-Institute of Water Resources Planning (MOARD-IWRP)
SIWRR	Southern Institute of Water Resources Research (MOARD)
SPC	*State Planning Committee (Abolished and integrated into the new MOPI)*
SRV	Socialist Republic of Viet Nam
UNDP	United Nations Development Programme
UNICEF	United Nations International Children's Education Fund
UNIDO	United Nations Industrial Development Agency
VPC (New)	Vietnam Power Corporation (the former General Company of Electricity of Viet Nam = EVN)
WASECO	Water and Sewerage Construction Company (MOC)
WB	World Bank
WHO	World Health Organization
WPMI (IWRPM)	Water Planning and Management Institute (MOARD)
WRD(or WRS)	Water Resources Department or Water Resouce Service (PC)
WSC	Water Supply Company (under Construction Services of the PC)

Note : Abbreviations in *Italics* are no more existent (already abolished and integrated in November 1995).

Measurements

Length

mm	=	millimeter
cm	=	centimeter
m	=	meter
km	=	kilometer
ft	=	foot
yd	=	yard

Area

cm^2	=	square centimeter
m^2	=	square meter
ha	=	hectare
km^2	=	square kilometer

Volume

cm^3	=	cubic centimeter
l	=	litre
kl	=	kilolitre
m^3	=	cubic meter

Weight

g	=	gram
kg	=	kilogram
ton	=	metric ton

Time

s	=	second
min	=	minute
h	=	hour
d	=	day
y	=	year

Electric Measurements

V	=	Volt
A	=	Ampere
Hz	=	Hertz (cycle)
W	=	Watt
kW	=	kilowatt
MW	=	Megawatt
GW	=	Gigawatt

Other Measures

%	=	percent
PS	=	horsepower
^{0}	=	degree
10^3	=	thousand
10^6	=	million
10^9	=	billion

Derived Measures

m^3/s	=	cubic meter per second
kWh	=	Kilowatt hour
MWh	=	Megawatt hour
GWh	=	Gigawatt hour
kVA	=	kilovolt ampere

Currencies

US$	=	US Dollar
VND	=	Vietnamese Dong

1. INTRODUCTION

1.1 Background

The Government of the Socialist Republic of Viet Nam launched an economic reform by proposing the Doi Moi policy, which gradually shifts from the planned economy to the market-oriented economy, in the Sixth Party Congress held in the year 1986. Since then, economic development is rapidly progressing along with democratic movement in politics.

Water resources development is one of essential elements to promote economic development, since the latter can be attained by using electricity and water gained through the development of the former. Thus, projects related to water resources have been developed in the framework of the national development programme based on the economic reform policy. In other words, water resources development is seemed to have concentrated in the northern Hanoi area and the Mekong delta zone to spur the economic development in the nation. In fact, a water resources master plan study like this Study has been or is being carried out only in those two areas.

The Dong Nai River basin including Ho Chi Minh City is a pivot of economic development in the southern Viet Nam called Nam Bo Region, since major cities and large industrial zones gather in the area. Therefore, it is desired for that area to make a plan of water resources development aiming at not only sustainable economic development, but also narrowing-down of prevailing economic disparity and enhancement of social well-being in the region. Available water resources are limited, and therefore this plan is desired to be prepared in such a form that available resources are efficiently utilized for such development and management objectives as hydropower, irrigation, water supply, flood mitigation and watershed management. Salinity intrusion will be discussed as part of water supply in Ho Chi Minh City and its nearby areas and irrigation development in the downstream reaches of the Dong Nai River, the Saigon River and the Vam Co River.

1.2 Objectives and Scope of the Study

The Government of the Socialist Republic of Viet Nam envisaged to carry out a master plan study on water resources development in the Dong Nai River and its surrounding basins taking into consideration not only national economic development but also regional development to aim at improving the living standard of local people, and requested to the Government of Japan technical cooperation in carrying out the master plan study.

In response to the request of the Government of Viet Nam, the Government of Japan decided to carry out the Study and sent a mission from Japan International Cooperation Agency (JICA),

the official agency responsible for the implementation of technical cooperation programmes of the Japanese Government, to Viet Nam for discussing the scope of work of the Study with the then Ministry of Water Resources, which became the Ministry of Agriculture and Rural Development in November 1995 by merging three ministries, in March 1994.

According to the scope of work along with its minutes of meeting so prepared under the discussions of two agencies as referred to Annex, the objective of the Study is to formulate a master plan for the Water Resources Development in the Dog Nai River and Surrounding Basins, which shall cover the Dong Nai main stream, four principal tributaries, Be River, Saigon River, La Nga River and Vam Co River, and adjacent coastal river catchments (refer to Location Map) with a land area of some 48,500 km^2.

Another objective of the Study is transfer of technology on planning and investigation to Vietnamese counterparts through their direct participation in the Study. In view of technical cooperation policies of Japan, this is in fact an essential objective of the Study.

The Study was carried out over a time period of 23 months from September 1994 to August 1996. For the smooth implementation of the Study, the time period of 23 months is divided into three phases. Main topics to be discussed during the three phases are as follows:

Phases	Major Objectives to Be Discussed	Period
Phase I	Inventory of Potential Sites for Water Resources Development	September 94 to March 95
Phase II	Selection of Master Plan Projects	May 95 to November 95
Phase III	Formulation of Master Plan	December 95 to August 96

Figure 1.1 presents the general work flow of the Study, in which work to be carried out in the field (Viet Nam) and at the home office (Japan) is shown.

1.3 Cooperation

The Study is conducted by a study team appointed by JICA in collaboration with the counterpart personnel assigned from the Sub-institute of Water Resources Planning, which belongs to the Ministry of Agriculture and Rural Development and is responsible for planning water resources development and management in the southern Viet Nam. JICA maintains an Advisory Committee for the Study in order to support the conduct of the Study Team. The Government of Viet Nam establishes a steering committee, which consists of high ranking officials of the Ministry of Agriculture and Rural Development, Ministry of Planning and

Investment, Ministry of Industry, Ministry of Construction and other ministries and organizations concerned, in view of the multi-disciplinary nature of the Study. Joint meetings are held among the Study Team, the Advisory Committee for the Study and the Steering Committee in due course to attain fruitful results from the Study.

1.4 Progress of the Study

Nippon Koei Co., Ltd. was selected as the consultant to undertake the Study based on the tender called by JICA, the pre-bid meeting of which was held on July 21st, 1994. An agreement for the Study was made on September 14th, 1994 between JICA and Nippon Koei after a couple of negotiations. Immediately after reaching the agreement, Nippon Koei commenced to prepare the Inception Report as preparatory home office work. Based on the Inception Report so prepared, a meeting was held in mid-September among the JICA Advisory Committee for the Study, JICA officials and the Study Team as part of preparatory home office work.

The first field work was commenced with the arrival of the Study Team in Hanoi on September 22nd, 1994. After the Study Team had the preparatory meetings with the ministries concerned including the then Ministry of Water Resources, a joint meeting was held on September 27th, 1994 for discussing the Inception Report, which deals with the basic concepts, work schedule and plan of operation for the Study among others.

After signing the minutes of meeting for the discussion of September 27th, 1994, the Study Team moved to Ho Chi Minh City to assume its duties in Viet Nam. The Progress Report (1), which summarizes study results gained through the first field work over a time period of September to December 1994, was prepared and submitted to the then Ministry of Water Resources. The Steering Committee, consisting of high ranking officials of Vice-Minister class of the ministries and agencies concerned, was convened on December 28th, 1994 to discuss the Progress Report (1).

After signing the minutes of meeting for the discussion on December 29th, 1994, the Study Team returned to Japan and started the first home office work over a time period of January to March, 1995. At the end of the first home office work, Interim Report (1) was prepared to summarize all the study results gained through the work of Phase I.

It is noted that an intensive salinity intrusion survey and a river survey, which prepares river cross sections and profiles, as well as the installation of seven rain gauges and three automatic runoff gauges were carried out parallel to the home office work of Phase I to reinforce the work to clarify the mechanism of salinity intrusion. The survey results were used for the salinity

intrusion analysis carried out in the work of Phase II. On the other hand, work to prepare 1 to 10,000 scale topographic maps for promising dam projects was cancelled due to availability of such a scale topographic maps for those promising dam projects.

The work of Phase II to be carried out over a time period of May 1995 to November 1995 was commenced with the arrival of the Study Team in Hanoi on May 22nd, 1995. A joint meeting was held on May 24th, 1995 to discuss the study results of Interim Report (1) and to deal with the work to be carried out in Phase II with the participation of the ministries concerned including the then Ministry of Water Resources, the JICA Advisory Committee for the Study, JICA official and the Study Team.

After the meeting, the Study Team moved to Ho Chi Minh City on May 28th, 1995 and resumed the field work in Phase II. During the course of field work, the second Steering Committee Meeting was convened in Hanoi by the Vietnamese Government with the attendance of the Study Team. Progress Report (2) was prepared and submitted to the then Ministry of Water Resources by incorporating the results and findings obtained through the field work of Phase II.

A meeting was held in Ho Chi Minh City on August 17th, 1995 for discussing Progress Report (2). After signing of the minutes of meeting, the Study Team left Viet Nam for Japan on August 19th, 1995 and resumed the home office work of Phase II over a time period of September to November 1995. At the end of the second home office work, Interim Report (2) was prepared by summarizing all the study results gained through Phases I and II, in particular by focusing on the optimal allocation of water available in the Dong Nai River basin.

The work of Phase III, which is scheduled to be carried out over a time period of nine months from December 1995 to August 1996, was commenced with the arrival of the Study Team in Ho Chi Minh City on December 1st, 1995. A joint meeting was held on December 13th, 1995 in Ho Chi Minh City to discuss Interim Report (2), of which one of main results is the selection of master plan projects which are expected to be developed over a time horizon of 20 years up to the year 2015. Immediately after receiving general consent from the Vietnamese side on the selected master plan projects, the Study Team commenced field work for those selected master plan projects. As part of field work, cross section survey and geological map preparation were undertaken for three dam projects included in the master plan projects. Furthermore, a workshop was held on January 4th, 1996 by the Vietnamese Government to discuss Interim Report (2) with the attendance of the Study Team.

Progress Report (3) was prepared and submitted to the Ministry of Agriculture and Rural Development by incorporating the study results gained through the field work of Phase III. A meeting was held to discuss Progress Report (3) with the Sub-Institute of Water Resources Planning on January 12th, 1996.

After signing the minutes of meeting on January 13th, 1996, the Study Team left for Japan and resumed the home office work of Phase III, through which Draft Final Report was prepared by incorporating all the study results gained through Phases I to III. The Draft Final Report emphasizes to proposes a comprehensive development plan of water resources available in the Dong Nai River and its surrounding basins in an efficient manner.

The Study Team returned to Viet Nam for nine days of May 23rd to 31st , 1996 to discuss the Draft Final Report with the Vietnamese Government. An internal meeting was held with the Sub-institute of Water Resources Planning on May 25th, 1996 in Ho Chi Minh City. Following the internal meeting with SIWRP, a joint meeting was convened in Hanoi on May 28th, 1996 with the participation of members of the Steering Committee dispatched from the ministries and other agencies concerned, the JICA Advisory Committee for the Study, JICA official and the Study Team. After signing of the minutes of meeting on May 29th, 1996, the Study Team returned to Japan on May 30th, 1996.

This Final Report was prepared by incorporating comments and requests raised to the Draft Final Report by the Vietnamese Government through the joint meeting held on May 28th, 1996, and was submitted to JICA at the end of August, 1996. With the submission of the Final Report, all the work of this Study was completed.

2. OVERVIEW OF VIET NAM

2.1 Natural Condition

2.1.1 Location

The Socialist Republic of Viet Nam extends along the eastern edge of the Indochinese peninsula, forming an S-shaped strip, bordering with China in the north and Laos and Cambodia in the west and facing the Gulf of Tonkin, the South China Sea and the Gulf of Thailand in the east, southeast and south respectively with a coastal length of 3,260 km. The main land, which occupies a land area of 331,114 km^2, stretches between 8°30' and 23°22' north latitudes with a length of 1,650 km and between 102°10' and 109°21' east longitudes with the maximum width of about 600 km in the northern part and with the minimum width of about 50 km in the central part.

Of the total international border line of 3,730 km with China, Laos and Cambodia, Viet Nam shares a length of 1,150 km with China, whilst a length of 1,650 km with Laos and a length of 930 km with Cambodia.

2.1.2 Physiography

According to sociology and geography, the nation is grouped into seven regions as depicted in Figure 2.1; North Mountains Region, Red River Delta and Midlands Region, North Central Coast Region, South Central Coast Region, Central Highland Region, North-East of South Region and Mekong River Delta Region.

The North Mountains Region, occupying a land area of 93,499.2 km^2, lies in the northeast part of the country with steep mountainous terrain. Major rivers draining in the region are the Red (Hong) River, the Bang-Xy Cung River and the Thai Binh River. This region has a poor socio-economic infrastructure, and only 10 % of its total area has been developed for agricultural production.

The Red River Delta and Midlands Region, sharing a land area of 21,976.1 km^2, extends in the lower reaches of the Red River with fertile alluvial flat lands and hilly and moderately elevated lands. The Red (Hong) and Thai Binh rivers drain in the region as major ones. This region is an important rice cultivation area of the nation. Due to high population density and small and decreasing farming area per capita, it is still difficult to meet food demands.

The North Central Coast Region with a land area of 51,187.6 km^2 shows hilly and long-stretched (northwest to southeast direction) topographic characteristics. The major rivers draining in the region are the Ca River, the Gianh-Huong River and the Ma River. In this

region, mountainous areas cover 83 % of the total land, and firming is lowest in the country due to low soil fertility and frequent strikes of typhoons and floods.

The South Central Coast Region, occupying a land area of 45,876 km^2, extends further south of the North Central Coast Region along the coast, showing hilly undulating terrain with flat plains at river valleys and estuaries. In fact, 70 % of its area is composed of land sloped over 15°, and furthermore climate difference is remarkable between the north and south areas as well as the coast and mountain areas. The Tra Khuc-Con River, the Cai-Luy River and the Vu Gia-Thu Bon River drain in the region as major ones.

The Central Highland Region, sharing a land area of 55,568.9 km^2, lies west of the South Central Coast Region, showing quite hilly terrain with dense forests. The region is blessed with high development potential. Major rivers in the region are the Mekong Srepok River, the Ba River and the Dong Nai River. This implies the southernmost part of the region is included in the Study Area.

The North-East of Southland Region, which is the major part of the Study Area and occupies a land area of 23,450.7 km^2, is surrounded by the Central Highland Region in the north, the South Central Coast Region in the east, the Mekong River Delta in the south and Cambodia in the west. The main river in the region is the Dong Nai River.

Agricultural development of this region has been slow in recent years and food production could satisfy only 50 % of demand, whilst industrial development of the nation focuses in the region.

The Mekong River Delta Region, sharing a land area of 39,555.1 km^2, lies in the southernmost part of the nation with flat lowlands for the whole of the region. This region is the largest rice granary area of the country and will play an important role in agricultural development, food stabilization and foreign exchange earnings. The Mekong River is the major river in the region, causing floods in the later stage of rainy season from August to October.

2.2 Socio-economic Condition

2.2.1 Population

According to the official statistics, the population of Viet Nam in the year 1994 was 71.5 million, which is translated to be 214 persons/km^2 in terms of population density as the national average with regional variations of 120 persons/km^2 in the North Mountain and Midland, 1,124 persons/km^2 in the Red River Delta, 190 persons/km^2 in the North Central

Coast, 167 persons/km^2 in the South Central Coast, 53 persons/km^2 in the Central Highland, 378 persons/km^2 in the North East of Southland and 401 persons/km^2 in the Mekong River Delta, showing dense population in the Red River Delta and sparse population in the Central Highland.

2.2.2 National Economy and Its Development Policies

Since the year 1986, the Vietnamese Government is carrying out drastic reforms in the political, economic and social fields under the banner of "Doi Moi" (renovation in Vietnamese), which has two major objectives to pursue in the economic field; 1) an economic liberalization policy at home and 2) an open door policy internationally, and includes the following reforms:

- Provision of long-term land tenure rights, facilitating household farming;
- Opening-up of opportunities for private sector development;
- Increased autonomy for state enterprises and requirements that they operate on a non-subsidized basis and in a competitive environment;
- Decontrol of prices, allowing market supply and demand forces to work;
- Devaluation of the official exchange rate;
- Trade liberalization and reorientation to export-led growth;
- Encouragement of foreign investment;
- Reform of the fiscal and monetary system, to better balance the budget, strengthen tax revenues, stimulate savings and control inflation; and
- Adoption of the new Constitution in the year 1992, introducing changes to democratic freedom and property rights.

The following present growth rates of Gross Domestic Product (GDP) recorded in major sectors over a period of the year 1989 to 1995:

Unit: % change

	1990	(share)	1991	1992	1993	1994	1995*	(share)
GDP	5.1	(100.0)	6.0	8.7	8.1	8.8	9.0 - 10.0	(100.0)
Agriculture	1.5	(38.8)	2.2	7.2	3.8	4.5	4.5 - 5.0	(26.6)
Industry	2.5	(22.6)	9.9	14.4	12.1	13.5	13.0 - 14.0	(30.3)
Service	10.4	(38.6)	8.3	8.6	9.9	11.0	12.0 - 13.0	(42.5)

Note: * Estimate
Source: State Planning committee (SPC)

With economic recession due to the shock occasioned by the collapse of the Soviet Union in the year 1990, the GDP declined from 8.0 % attained in the year 1989 as the result of Doi Moi

policy to 5.1 % in the year 1990 and 6.0 % in the year 1991. However, the economy fully recovered and climbed to 8.7 % in the year 1992 and healthy growth continued in the year 1993 and 1994 with 8.0 % and 8.8 % rates. In the year 1994, GDP recorded in Viet Nam was estimated at VND 170,258 billion, which is equivalent to US$ 15.5 billion (refer to Table 2.1). This no doubt considerably understates the GDP actually gained, since there is large informal economy.

About the future GDP growth rates of Viet Nam, there are several different projections, both optimistic/ambitious and probable (refer to Table 2.2). Some forecast 8 to 9 % of GDP growth to the year 2010. On the other hand, the economic growth rates that World Bank forecast for total economy over the period of the year 1990 to 2012 are ranging from 6.0 % on the average in the most probable scenario to 7.2 % on the average in the most optimistic scenario (refer to 2/2 of Table 2.2).

At present, there are two principal socio-economic development plans in Viet Nam; one is for short-term and the other is for medium-term up to the year 2000. As the short-term development plan, the Vietnamese Government is preparing the Sixth Five-year Socio-economic Development Plan to be put into execution from the year 1996 to 2000. During the next five years, Viet Nam plans to achieve high and sustainable growth at a rate higher than the previous five years so as to:

- fulfill the objective of doubling the year 1990 per capita GDP by the year 2000,
- bring the country out of poverty and underdevelopment,
- improve people's living standards, and
- increase domestic savings to get ready for stronger development in the 21st century.

Basic objectives and tasks set an annual GDP growth rate of 10 % with the target of each sector as follows:

- agriculture/forestry and fishery: 4.5 % to 5 %
- industry: 13 % to 14 %
- service: 12 % to 13 %.

By the year 2000, the share of industry in GDP will double that of agriculture, and the share of service will be 47 %.

As a medium-term plan, there is the "Socio-economic Stabilization and Development Strategy to the year 2000" which sets out/determines the basic framework for the development of Viet Nam. The Strategy aims to:

a) stabilize and develop socio-economy,
b) improve the people's living standard,

c) rid the country of poverty and underdevelopment , and

d) prepare basic conditions for a rapid development in the early 21st century.

This strategy has set people - as a community - into central position, i.e. the strategy for people and by people.

2.3 Institution

2.3.1 Administrative Division

Administratively, Viet Nam is divided into central and local levels. The latter comprises provinces with a relatively high degree of autonomy. Under the provinces, there are districts and communes. Large cities such as Hanoi and Ho Chi Minh City, of which the former is the capital of Viet Nam located in the north (Red River Delta Region) and the latter is a large economic, cultural and commercial centre of Viet Nam situated in the south (North East of South Region), have the same status as provinces. At present, there are 53 provinces and cities with 467 districts and 9,670 communes/precincts.

In terms of development, region can be treated as a spatial unit and province similarly treated. Administratively, only province is treated as a unit, which is governed by Provincial People's committee.

A commune is the sub-division of a district belonging to the province, and a precinct is the sub-division of a district belonging to the city.

2.3.2 Laws and Regulations Related to Water Resources Development

The previous laws on water resources development (river control, watershed management and so on) were unclear and had neither been successful in optimizing its use nor in preventing actions which waken the risk of water disaster.

In November 1994, new "laws on exploitation and protection of water resources schemes" were prepared in order to strengthen the efficiency of governmental management in exploiting, repairing and preserving water resources schemes for production and socio-economic development and consequently to contribute to the social safety and national security.

There are four major pieces of government legislation on environmental protection, and those related to water resources development are:

- Environmental Protection Law,

- Prime Minister's Decree on Environmental Protection,
- Guidelines for Environmental Impact Assessment (EIA), and
- Environmental Quality Standards.

In addition to the above, there are a number of other pieces of existing or proposed government legislation and policy that are relevant to environmental protection and management. Those are:

- Forest Protection and Development Law,
- Mining Law (draft under preparation by the Ministry of Industry),
- Industrial Waste Water Guidelines (draft prepared by IWRP-MOARD), and
- Sustainable Energy Policies.

The Land Law enforced in the year 1993 provides that land use certificates will be issued for agricultural land and urban residential land and that these certificates can be sold, leased, inherited and mortgaged. Laws and regulations related to water resources development are the following:

- Law on Environmental Protection (December 1994),
- Water Quality Management Law (to control pollution by waste water), and
- Regulation on Environmental Pollution Control in HCMC (May 1993).

2.3.3 Agencies for Water Resources Development

In October 1995, eight ministries and agencies related to water resources development were revamped to create the following three new ministries:

a) Ministry of Agriculture and Rural Development (MOARD):
   created from the merger of the former Ministry of Water Resources, Ministry Agriculture and Food Industry and Ministry of Forestry,
b) Ministry of Industry (MOID):
   created from the merger of the former Ministry of Energy, Ministry of Heavy Industry and Ministry of Light Industry, and
c) Ministry of Planning and Investment (MOPI):
   formed from the merger of the former State Planning Committee (SPC) and State Committee for Cooperation and Investment (SCCI).

The resolution to revamp certain government agencies was approved in October 1995 by the deputies at the eighth session of the National Assembly, and a number of cabinet members have been appointed.

This restructuring aims to separate the state management from production and business for the following two reasons:

a) to enhance the role of state management and the macro management by ministries and
b) to allow businesses to have independent finance, investment and marketing.

As a result of restructuring, ministries are now "state management bodies" whilst businesses are run by "General Corporations" newly established.

Many government agencies and institutions are related to water resources development and management as depicted in Figure 2.2, and their functions and responsibilities can be broadly defined as follows:

Agencies / Institutions	Functions & Responsibilities
1) Ministry of Agriculture and Rural Development (MOARD)	- Management of surface water (only water source) - Management of industrial-domestic water and water quality - Security of water sources for agriculture, hydropower generation, water supply, etc. - Stormwater and rainwater control - Irrigation and drainage - Forestry development and control - Population distribution and resettlement
- Institute of Water Resources Planning (SIWRP)	- Water resources planning for basins and zones - Formulation of water resources development investigation projects - Water resources management - Thematic studies on water resources
2) Ministry of Construction (MOC)	- Planning, design, construction and management of facilities for urban water supply, sanitation, urban roads, public light, etc. (As for the planning, design, construction and management of facilities for industrial water supply, each industry concerned is responsible for them)
3) Ministry of Industry (MOID) & Viet Nam Power Corporation (VPC)	- Electric power generation - Development of power industry - Development and management of groundwater and other underground resources
4) Ministry of Science, Technology and Environment (MOSTE)	- Environmental control and management (Water quality)
5) Ministry of Public Health (MOPH)	- Monitoring of water quality and hygiene
6) Provincial and City People's Committees	- Planning and management are decentralized to provincial institutions, which increase autonomy and responsibilities.
- Water Resources Services	- Local water resources development
- Agriculture and Forestry Services	- Operation and management of irrigation schemes

3. SOCIO-ECONOMIC CONDITIONS IN THE STUDY AREA

3.1 Administrative Division and People

3.1.1 Administrative Division

The Study Area, covering the Dong Nai River and its surrounding river basins with an area of some 48,500 km^2 or sharing 14.6 % of the total land area of the country (331,114 km^2), extends over one city and nine provinces of southern Viet Nam; Tay Ninh, Song Be, Dac Lac, Lam Dong, Ninh Thuan, Binh Thuan, Ba Ria-Vung Tau, Dong Nai, Ho Chi Minh City and Long An. Administrative boundaries of these one city and nine provinces are given in Figure 3.1 with provincial and district capitals, whilst Table 3.1 shows a summary list of provinces and districts in the Study Area.

Con Dao district in Ba Ria-Vung Tau province and Phu Quy district in Ninh Thuan province are out of the Study Area due to the islands scattered in the South China Sea. Of 17 districts in Dac Lac province, an entire area of Dak Nong and Dak R'Lap districts is included in the Area, whilst forest areas of Lac Duong district in Lam Dong province lie out of the Study Area. In Long An province, included in the Study Area are nine districts, of which Thu Thua, Thanh Hoa and Moc Hoa districts partially lie in the Study Area.

3.1.2 Population

The population in the Study Area is estimated at some 11.7 million in the year 1994 as summarized in Table 3.2, accounting for 16.3 % of the total population of the nation. Average population density in the Study Area is about 241 persons per km^2 with the highest rate of 2,101 persons per km^2 in Ho Chi Minh City and low rates of 61 persons per km^2 in Dac Lac province and 76 persons per km^2 in Lam Dong province in the Central Highlands. Majority in these sparsely populated areas is minority groups.

Population in the Study Area grew at a rate of 2.74 % per year between the year 1979 and 1989, which was faster than that of the nation at 2.01 % per year for the same period as given in Table 3.3. Despite fast economic growth, population in the Study Area is estimated at gradually decreasing rates of 2.68 % over a period of the year 1993 to 2000, 2.44 % over a period of the year 2000 to 2005, 2.23 % over a period of the year 2005 to 2010 and 2.00 % over a period of the year 2010 to 2015, resulting in a total population of some 19.3 million in the year 2015 and accounting for 18.0 % of total population in the nation.

3.1.3 Ethnic Groups

It is considered in Viet Nam that there are more or less 60 ethnic groups besides ethic Vietnamese (Kinh), which is the dominant ethnic group in number, about 90 % of the total population in the nation, well spreading over the Study Area. The second largest group in the Study Area is Hoa (Han), accounting for 5.8 % of the total population. Over 90 % of them dwell concentratedly in Ho Chi Minh City and Dong Nai province.

Remaining major minority groups are Cham, Co Ho, Ra-glai, Xtieng, Ma, Cho-ro and Chu-ru among others. Most of ethnic minority tribes live in the marginal highlands, keeping their own living style and customs which are well traditionally refined.

3.2 Infrastructures

Road network in the Study Area is developed by placing Ho Chi Minh City as its centre (refer to Figure 3.1). National Highway No. 1, which links between Ho Chi Minh City and Hanoi, runs in the coastal area through major towns of Bien Hoa, Phan Thiet and Phan Rang. Another main route from Ho Chi Minh City to Hanoi is National Highway No. 20, which passes in the hilly area of Dong Nai and Lam Dong provinces through Da Lat.

National Highways No. 13 and No. 22, which go through Tay Ninh, are the access roads to Cambodia, whilst National Highway No. 14 leads to Laos through Play Ku. National Highway No. 4 is used for accessing to large towns in Mekong Delta such as Can Tho and My Tho through Tan An. It is noted that National Highway No. 51 linking Bien Hoa and Vung Tau constitutes part of the artery of the so-called economic triangle zone in the Study Area.

Railway service, which links Ho Chi Minh City to Hanoi, runs along National Highway No. 1 in the Study Area. Due to slow speed resulting from aged track, railway service is less reliable than vehicle as transportation means. There are two ports in the Study Area, i.e. Saigon and Vung Tau ports, for ocean freight. In particular, the Saigon port, transaction amount of which exceeds 3 million ton a year, acts as a pivot of economic activities in southern Viet Nam. Meanwhile, there are two airports in the Study Area; Tan Son Nhut air port in Ho Chi Minh City and Da Lat airport. The former is used as a gateway to and from foreign countries, whilst domestic flights only for the latter.

3.3 Quality of Life

3.3.1 Education

In the year 1989, there were 2,442 primary and secondary schools with 73,509 teachers in the Study Area, which are compared with 15,386 primary and secondary schools and 439,161 teachers in the nation. This fact is translated into 543.9 students per school and 22.4 students per teacher in the Study Area.

Relying on the high number of schools and teachers, most of the population has received a basic level of education as endorsed by the high literacy rate of 88.0 % in the nation. In the Study Area, the rate variates in the range of 93.2 % in Ho Chi Minh City to 80.8 % in Dac Lac province. According to the 1989 Population Census, 46.7 million or 83.0 % of people aged 10 years and over have attended or are attending an educational institution, while the comparative ratios increase for the younger generation between 10 and 39 years old with a figure of 92.9 % and decrease to 72.0 % for people 40 years old and over. Of the 40.6 million that have attended educational institutions, 1.6 % have graduated from colleges and universities (some completing post graduate courses), 2.9 % have completed middle vocational school, 6.8 % have completed secondary school and 27.2 % have completed primary school.

3.3.2 Public Health

There are two types of medical doctors in Viet Nam; one is the doctor graduated from the medical school of university and the other is the doctor graduated from the medical technical school. The former doctor has the number of 3,279 in the Study Area, accounting for 20.0 % of the total number in the nation, whilst 6,579 for the latter, accounting for 16.3 % of the total number in the nation. On the other hand, the number of nurses and midwives registered in the Study Area is 10,930 and 2,847 respectively.

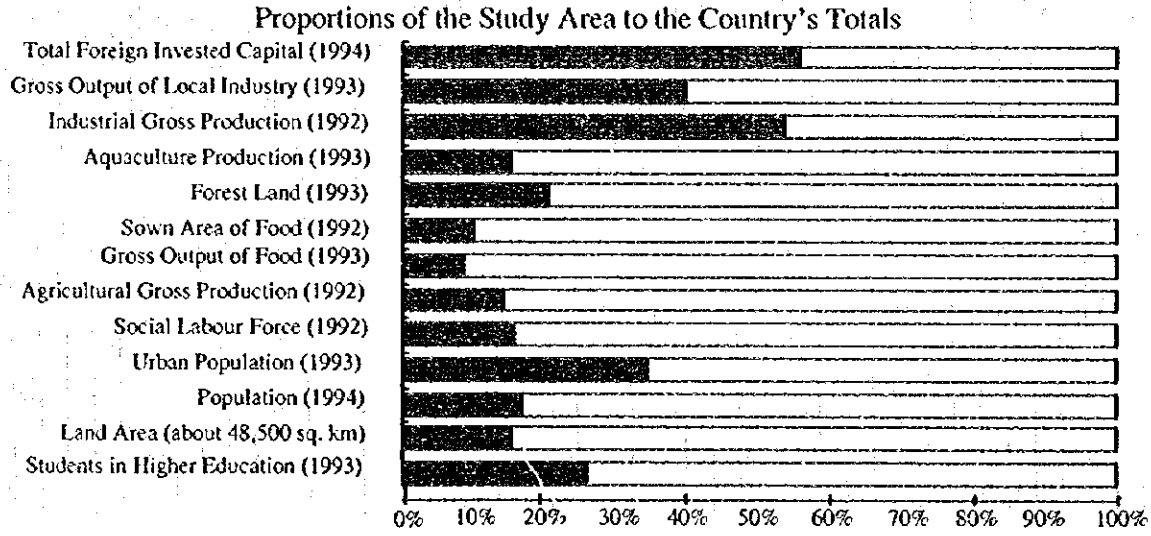
Even under the medical service condition in the Study Area mentioned above, the nutritional status of Vietnamese population is low. This is proved by the fact that daily per capita energy intake, estimated at 2,280 kilocalories in the year 1985, is lower than the average intake of 2,460 kilocalories in developing countries. Food shortages had been a major problem contributing to chronic malnutrition. Although the recent improvement of food self-sufficiency has reduced this problem, acute malnutrition has significantly increased mainly due to a failure of the food distribution and public health delivery systems in food-deficit areas.

Safe drinking water and adequate sanitation facilities are less developed in the Study Area. Due to this, water-borne and hygiene-related diseases such as gastro-enteritis, diarrhoea, typhoid, cholera and hepatitis are still widely prevailed in the Study Area. Furthermore, many cases of vector-borne diseases such as malaria and dengue fever are also reported.

3.4 Position of the Study Area in the National Socio-economy and Spatial Development

3.4.1 Position in the National Socio-economy

The socio-economic indices summarized below characterize basically the Study Area and define globally its position in the country:



The population in the Study Area is 11.7 million in the year 1994, accounting for 16.3 % of total population of the nation. Meanwhile, the gross production ratio of the Study Area to the national total was 14.2 % in agriculture and 53.5 % in industry in the year 1992. For the value of exports in foreign trade, the Study Area accounts for 21.7 % to the national total in the year 1992. Excepting the figure in agricultural gross production, these are substantially larger than the territorial share of Study Area at 14.6 % (some 48,500 km^2 out of the national land: 331,114 km^2).

The economic triangle zone, connecting Ho Chi Minh City-Bien Hoa-Ba Ria-Vung Tau areas, constitutes one of the key economic growth areas in Viet Nam. This economic growth zone is the biggest area in oil and gas exploitation, and processing. In this area, the industry

specialized in high-quality consumer goods will be developed for export and supplying to other areas with such products as electronic and domestic appliances, textile, ready-made clothes, motor-bikes, processed farm produce, maritime products and so forth.

3.4.2 Position in the National Spatial Development

The Study Area holds an important position in the national development due to following factors:

a) More urbanized and more rapidly urbanizing region,
b) Receiving area of spillover from HCMC and for in-mitigation from the northern regions,
c) More concentrated urbanization pattern, and
d) Crossroads or gateway to Indochina countries.

The ratio of urban population to the total population or the urbanization ratio is as high as 40.3 % in the Study Area in the year 1993 mainly due to that of Ho Chi Minh City (74.0 %), the highest of all 53 provinces and cities (refer to Table 3.3). The Study Area contains 33.7 % of the total urban population in the country.

The Study Area includes parts of migration receiving regions like the Central Highlands (Lam Dong), Mekong River Delta (Long An) and South Central Coast (Binh Thuan and Ninh Thuan). The organized migration projects and migration to new economic zones are actively promoted in these areas.

The Study Area is not only more urbanized, but its urbanization pattern is more concentrated. Three broad areas of urban population concentration may be identified: 1) Ho Chi Minh City (HCMC) itself, 2) areas leading to Bien Hoa and along National Highway No. 1, and 3) areas leading to Ba Ria-Vung Tau along National Highway No. 51 (refer to Figure 3.1). In addition to the above conurbations, Da Lat which is famous as highland resort in the central highlands (Lam Dong province) also forms a relatively urbanized agglomeration.

Another key for continued development of the Vietnamese economy is how to make effective use of emerging opportunities for economic interactions with the Indochina countries (especially Cambodia and Thailand). The Study Area is in a pivotal position to take advantage of these opportunities.

3.5 Socio-economic Development Framework of the Study Area

3.5.1 Development Scenarios and Framework

Three distinct alternatives might be envisioned for the socio-economic development of the Study Area as follows:

a) Trend development

This alternative represents the continuation of what has been taking place in the Study Area in the recent past.

b) Accelerated development

This alternative is to attain the highest economic growth placing emphasis on high industrialization/urbanization and border trade related services.

c) Balanced development

This alternative represents a well-controlled path between the first two alternatives, paying due attention to the balanced and sustainable regional development (not only the whole country but also with the Study Area).

Given the rich natural and human resources, the Study Area as a whole has recorded higher economic growth rates compared to the whole country. Besides, in view of its large potentials, the area is expected to continue to develop keeping more or less the presently enjoyed growth rates up to the target year 2015. However, it is apprehended, on the other hand, that such strikingly accelerated growth led by the Ho Chi Minh City area might skew the balanced and sustainable development and generate more large regional disparities/differences. Thus, the third alternative, i.e. balanced development, seems to be the most desirable and realistic one. The development scenario in this master plan is further elaborated for this alternative.

The socio-economic framework for the balanced development alternative compared with the future growth rates set out in the national socio-economic development plans and other existing projections are shown in the following Table:

Proposed National Macro-Economic Framework and Projections

Sector	Viet Nam 1995	2000	2005	2010	2015	Share of the Study Area (Balanced Dev.)
Population (Thous.)	74,285	83,230	91,443	99,485	107,173	16.4 - 18.0 %
(Growth rate)	(2.3 %)	(1.9 %)	(1.7 %)	(1.5 %)		
GDP (Bil. VND, 1989 price)	43,166	61,970	95,348	140,098	196,495	40 - 48 %
GDP Growth Rate(%)	(7.5 %)	(9 %)	(8 %)	(7 %)		-
- Agriculture	(10-12 %)	-	-	-		5 - 10 %
- Industry	(4.0-4.4 %)	-	-	-		40 - 50 %
- Service	(7.8-8.0 %)	-	-	-		40 - 55 %
Per capita GDP (VND per person)	581,080	744,561	1,042,706	1,08,237	1,833,431	-

Source : Socio-Economic Stabilization and Development Strategy to the Year 2000 and the Study Team's estimate

Notes : Figures in parentheses are the estimated growth rates between the years.

3.5.2 Development Targets

In accordance with the above development scenarios and framework, macro targets for the Study Area are set for the years 1995, 2005, 2010 and 2015 as shown in the following Table:

Macro-Economic Targets of the Study Area

Year		1993	1995	2000	2005	2010	2015
Population	Population (thousand)	11,406	12,026	13,726	15,484	17,290	19,089
	Annual Population Growth Rate (%)		(2.83%)	(2.68%)	(2.44%)	(2.23%)	(2.00%)
	% Urban Population	40.3 %	42 %	44 %	46 %	48 %	50 %
GRDP	GRDP (Billion VND at 1989 price)	14,694	17,458	25,651	41,312	63,653	93,396
	Annual GRDP Growth Rate (%)		(9%)	(8%)	(10%)	(9%)	(8%)
	% Changes by Sector						
	- Agriculture	10 %	10 %	8 %	7 %	6 %	5 %
	-Industry	50 %	50 %	45 %	43 %	42 %	40 %
	-Service	40 %	40 %	47 %	50 %	52 %	55 %
	Per capita GRDP (VND)	1,274,194	1,435,876	1,848,444	2,638,894	3,636,324	4,839,277

Source : JICA Team's estimates

Major considerations taken into account in target setting are as follows:

a) Population

As viewed in the world experiences, average population growth rate will be decelerated in a long term. Population is targeted to grow at rates of 2.68 % in the year 1995 to 2000, 2.44 % in the year 2001 to 2005, 2.23 % in the year 2006 to 2010 and 2.00 % in the year 2011 to 2015. At the target year 2015, the total population of the Study Area is estimated to reach approximately 19.1 million.

b) Gross Regional Domestic Product (GRDP)

Vietnamese economy is now growing fast at a rate of 8.4 % per annum during the time period of the year 1991 to 1993. The long-term macro economic projections by the World Bank and Vietnamese authorities indicate growth rates of 6.6 % to 12~13 % during the time period of the year 1995 to 2012 as most probable forecasts. Having these in mind, the economic growth in the Southern Region including Study Area is assumed at 8 % to 10 % for the time period of the year 1995 to 2015.

c) Per Capita GRDP

Per capita GRDP of the Study Area was VND 1,274,194 in the year 1993. This was higher than the national average of VND 517,522 by 2.46 times, and the gap has been widening. During the time period of the year 1995 to 2015, it is forecast that per capita GRDP growth of the Study Area will increase at an annual average of 6.26 % against 5.91 % of the national average.

4. NATURAL CONDITIONS IN THE STUDY AREA

4.1 Topography and Geology

4.1.1 Topography

The main stem of the Dong Nai River originates from the high hills (El. 1,000 to 2,000 m) lying in the northern end of Lam Dong province, initially taking the southwestward direction in its flow course (refer to Location Map). After the join of the Da Dung River from east, the Dong Nai River turns its flow direction to west, making the border line between Lam Dong and Dac Lac provinces.

After passing counter-clockwisely along the border lines between Dac Lac and Lam Dong provinces and between Lam Dong and Song Be provinces, the Dong Nai River heads its flow direction to south-east. After the join of the Da Te River from north-east, the Dong Nai River changes its flow direction to south-west, and crosses Dong Nai province. Meandering east of Ho Chi Minh City, the Dong Nai River finally debouches in the South China Sea with a catchment area of 40,683 km^2 at the estuary including tributaries.

There are two main tributaries, the La Nga and Be rivers, in the Dong Nai River besides the Saigon River meeting into it about 30 km upstream of the estuary and the Vam Co River merging into it almost at the estuary. The La Nga River originating from the south-west flank of Mt. Pantar (El. 1,654 m) in Lam Dong province lies in the south of the Dong Nai River basin. Meandering westwardly, the La Nga River merges into the Dong Nai River at Thanh Son.

The origin of the Be River lies in the Tuy Duc mountain area (El. 950 to 1,000 m) standing on the international border between Viet Nam and Cambodia in Dac Lac province, and its main tributary called the Dac Hoyt River runs south-westwardly by forming the international boundary between the two countries. The Be River meets the Dong Nai main stem downstream of the Tri An damsite after passing the wide valley extending in the centre of the Song Be province.

The Saigon River, which originates from the southern flank of the hill (El. 100 to 200 m) bordering with Cambodia in Tay Ninh province, has characteristics of gentle slope and meandering. Five km upstream of the confluence with the Dong Nai, there is the Saigon inland port, which is the pivot of navigation to support the economic activities in Ho Chi Minh City and the Mekong Delta.

In the west of the Saigon River, there is the Vam Co River, which has two main tributaries; the East Vam Co River and the West Vam Co River. Both of them originate in the low hill area

lying in Cambodia and gently flow down south-eastwardly through the wide plain extending in the Long An province, finally merging into the Dong Nai River near the estuary.

In the coastal zone of the Study Area, south of La Nga River basin, there are several rivers such as Cai, Rui, Phan, Dinh and Rai, which directly debouch in the South China Sea. Due to small catchment area, i.e. 1,000 to 2,000 km^2, these rivers are not well utilized in terms of water resources development.

4.1.2 Geology

Central to southern part of Viet Nam is situated on the Indosinian Platform, the central core of so-called Indosinian Continent that was built up by Mesozoic orogenesis and has been established up to the present time. Basement rock of this region is metamorphic rocks of Late Pre-Cambrian to Early Paleozoic, which are covered by folded sedimentary rocks of Paleozoic to Mesozoic eras. Also widely distributed are intensive granites and volcanic rocks including andesites and basalts, formed in the course of the orogenic movement. While Tertiary sediments are very limited in distribution, Quaternary deposits are located at many places along rivers. Especially in the southernmost part of the country thick Quaternary deposits are formed in an extensive plain of 100 km in width developing from the Mekong Delta North-West toward Cambodia.

From the geological point of view, the Study Area can be divided into three regions, i.e. the Dong Nai River basin including the La Nga River basin, the Be River and Vam Co River basins and the coastal zone. The geological conditions of the Study Area are illustrated in Figure 4.1 and stratigraphy is presented in Table below:

Sedimentary Deposit/Rocks

Cenozoic	Quaternary		Deposit not cemented, clay, silt, sand and gravel
	Neogene		Siltstone and mudstone
		Di Linh	Sandstone with cobble and siltstone, mudstone containing coal and organic matters
Mesozoic	Cretaceous	Dong Duong	Rhyolite, dacite, tuff and sandstone
		Bao Loc	Andesite, dacite, tuff and sandstone
	Jurassic		
		Ban Don	Mainly siltstone, sandstone and clayey schist
Paleozoic	Permian	Ta Thiet	Sandstone, conglomerate, clayey schist and limestone

Igneous Rocks

Geological	Time	Formation	Geological Description
Cenozoic	Quaternary		Olivin basalt
			Dolerite basalt and olivine basalt
	Neogene		
Mesozoic	Cretaceous		Granite and diorite

Geological field reconnaissance was carried out for six out of 17 proposed damsites during 22 to 29 November 1994 in collaboration with SIWRP. On the basis of collected data, field reconnaissance results and topographic and geological maps, geological conditions of the proposed damsites, the location of which is referred to Figure 4.2, are summarized in Table 4.1.

4.1.3 Hydrogeology

In terms of hydrogeology, the Study Area can be divided into five areas, lower plain area, central plateau area, granite-diorite area, coastal area and mountainous area as shown in Figure 4.3. The lower plain area, situated on the eastern margin of the Mekong Delta covering Tay Ninh, Long An, Ho Chi Minh City and some parts of Song Be and Dong Nai provinces, is characterized by flat terrain and overlain by unconsolidated sedimentary deposits of Neogene-Quaternary ages. Among the sedimentary deposits, there exist five layers, mainly composed of sand and gravel, and are judged to have ample aquifers.

The central plateau area, characterized by gentle hill land and formed by basalt lavas erupted in Neogen-Quaternary ages, covers the upstream reaches of the Be River and some parts of Dac Lac, Dong Nai, Lam Dong and Ba Ria-Vung Tau provinces. The basalts are 20 to 100 m thick, and layers bearing groundwater are identified as fissure and porous zones horizontally extending in the basalts.

The granite - diorite area, sporadically situated on the eastern part of the Study Area and composed of granite and diorite, covers some parts of Lam Dong, Ninh Thuan and Binh Thuan provinces. Although only fractured zones formed by fault activities and cooling joints are identified as aquifer and are recharged with rain water, large scale development of groundwater in the area is not recommendable due to the limited areas of aquifer.

The coastal area, overlain by Quaternary fluvial deposit such as clay, sand and gravel and also sand dune along the 10 to 20 km wide seashore, covers south of Ninh Thuan and Binh Thuan provinces. The Quaternary deposits with 20 to 40 m in thickness are judged to be a small scale aquifer in terms of thickness.

The mountaineous area is characterized by the mountain range formed by Cretaceous-Permian sedimentary rocks. Aquifer can scarcely be found in the area except for the fissure zone and river-bed deposit, resulting in less possibility of large scale development of groundwater.

Groundwater is tapped by two types of wells, i.e. dug well and tube well, for domestic and industrial use in the Study Area. Dug well, around 1 m in diameter on an average, can be found very easily in the whole Study Area as a private well used in each family except for mountain region. Tube wells can be divided into two groups basically; one is for water supply to urban area and industrial zones with 250 mm in diameter, 50 to 300 m in depth and a capacity of 15 to 50 m^3/ hour. The other, for domestic use, is 40 to 80 mm in diameter and 30 to 40 m in depth in general.

As of the year 1993, groundwater of an amount of some 640,000 m^3/day is estimated to be lifted in the Study Area; about 300,000 m^3/day for domestic and industrial uses and about 340,000 m^3/day for the use in the rural area.

Development potential and possible yield of groundwater are evaluated to estimate its future use. Development potential, which is equivalent to annual recharge, is estimated by subtracting runoff and evapotranspiration from precipitation. Possible yield, which expresses exploitable amount, is assumed to be 0.6 times of development potential. Following shows the estimated result of development potential and possible yield of groundwater in the Study Area by province:

Unit: m^3/day

Province	Development potential of groundwater	Possible yield of groundwater	Present use of groundwater	Present use Potential
Tay Ninh	6,287,807	3,772,684	52,567	0.014
Song Be	5,078,042	3,045,625	108,935	0.036
Dac Lac	6,895,097	4,137,058	9,458	0.002
Lam Dong	7,391,228	4,434,737	30,498	0.007
Ninh Thuan	306,828	184,106	19,760	0.107
Binh Thuan	7,934,293	4,780,576	34,305	0.007
Ba Ria-Vung Tau	3,260,289	1,956,161	21,840	0.011
Dong Nai	9,312,207	5,567,324	112,130	0.020
Ho Chi Minh City 1)	3,523,881	845,731	207,998	0.246
Long An 2)	2,772,358	1,081,220	27,446	0.025
	61,591,928	29,805,222	644,481	0.022

Note: possible yield of groundwater = Pw x 0.6

1) possible yield of groundwater = Pw x 0.6 x (1 - 0.60)

2) possible yield of groundwater = Pw x 0.6 x (1 - 0.35)

The above Table tells that there is large room to develop groundwater in the Study Area since a present groundwater use of 640,000 m^3/day is only 2.2 % of total possible yield estimated at 29,800,000 m^3/day. In proposing concrete development projects of groundwater, detailed assessment on aquifer, recharge and water quality is however necessary at the site where groundwater is actually exploited.

Figure 4.4, showing the development potential of groundwater in the Study Area, is prepared based on the data and information obtained by the Study Team, indicating that Lower plain and Central plateau areas, where basalt extends, are promising for development of groundwater.

4.2 Meteorology and Hydrology

4.2.1 River System

The Study Area is divided into seven basins/zones; river basins of the Dong Nai, Saigon, Be, La Nga, West Vam Co and East Vam Co, and the coastal zone covering Binh Thuan, Ninh Thuan and Ba Ria - Vung Tau provinces (refer to Figure 4.5). The catchment area of these basins/zones obtained from the topographic map of 1:250,000 is measured at 48,471 km^2 in the Study Area as summarized below:

River	Definition of Catchment Area	Catchment Area (km^2)	Study Area (km^2)
Dong Nai	confluence at the Be River including the La Nga River basin	14,979	14,979
Dong Nai	from the confluence at the Be River to the estuary	4,093	4,093
Be	confluence at the Dong Nai	7,427	7,201
Saigon	confluence at the Dong Nai	4,717	4,316
West Vam Co	confluence at the East Vam Co excluding the west bank area	921	921
East Vam Co	including the estuary	8,546	5,005
Coastal zone	estuaries with north-eastern bound of Khanh Hoa/Ninh Thuan province	11,956	11,956
	Total	52,639	48,471

It is noted that an area of 4,168 km^2, which is the difference between the catchment area and the Study Area, lies in Cambodia.

4.2.2 Meteorology

(1) Available Data and Records

Officially, both meteo- and hydro-data are collected by the General Department of Meteorology and Hydrology. However, other governmental agencies such as Power Company No. 2 under the Ministry of Industry, the Ministry of Agriculture and Rural Development, Economic Institute, etc., are also collecting hydrological data at the sites of their interest, which sometimes are very crucial data for a basin planning.

Here is the discussion on meteorological data collected during the study period as well as their availability.

- Rainfall data
  There exist 74 rain gauges in the Study Area (refer to Figure 4.6); five in the Be River basin, ten in the Saigon River basin, six in the East and West Vam Co River basins, 13 in the La Nga River basin, 23 in the Dong Nai River basin and 17 in the coastal zone. Of 74 rain gauges, monthly rainfall data are collected from 36 gauging stations, which are considered as the representative ones mainly because of the sufficient number of years for the observed duration.

- Climate data
  In the Study Area, there are 20 climate stations (refer to Figure 4.7) observing air temperature, evaporation by Piche, relative humidity, wind direction and velocity and sunshine hours. Collection is made for those data on monthly basis.

(2) Climate

The Study Area is located in the tropical monsoon zone. In the time period of May to October, a high prevailing pressure in the central Asia forms South-West monsoon, bringing humid air from the Thai Gulf to the Dong Nai River and surrounding river basins and causing the rainy season. The North-East monsoon brings northern dry wind from the Asian Continent during the period of November to April when the southern hemisphere is in summer. This dry wind does not create considerable precipitation to the Study Area, bringing the dry season.

(3) Rainfall

An isohyetal map is prepared based on the monthly rainfall records of the 36 representative gauges in the Study Area as well as some additional mean annual rainfall records obtained from various sources (refer to Figure 4.8), showing a mean annual rainfall of 1,945 mm. Furthermore, the isohyetal map reveals that the highest rainfall is measured in and around the Dac Te River with 2,800 mm a year. The mean annual rainfall decreases gradually toward the south-west direction and reaches 1,400 mm at the estuary of the Dong Nai River. On the contrary, the mean annual rainfall decreases hastily toward the south-east direction, i.e. the coastal area, and reaches less than 800 mm around the Phan Ri-Mui Dinh area.

Using a total of 12 rain gauges, which are well scattered in terms of aerial distribution with the long-term observation and are selected from among 74 existing rain gauges in the Study Area, the annual maximum point rainfalls of 1, 2, 3, 4, 10, 15 and 20 continuous days for those 12 stations are computed in this study, and following summarizes the estimated probable rainfalls of those 12 stations with a return period of 20 and 100 years for 1-day and 3-day durations:

	Probable Rainfall			
	1-day rainfall (mm)		3-day rainfall (mm)	
Station	20-year	100-year	20-year	100-year
Di Lin	139.8	182.6	201.5	258.9
Bien Hoa	143.6	176.4	217.0	270.4
Da Lat	209.8	289.3	302.3	407.6
Dau Tieng	203.3	263.1	265.0	333.0
Long Thanh	199.6	259.9	269.7	344.1
Phan Thiet	134.3	172.2	185.2	236.7
Phan Rang	192.9	256.4	278.0	368.5
Tan Son Nhat	133.6	160.3	191.7	226.3
Tay Ninh	145.6	178.8	213.4	261.7
Phuoc Long	195.1	247.3	249.3	300.4
Vung Tau	171.0	220.6	215.6	271.2
Xuan Loc	201.8	268.4	257.9	329.2

The Da Lat station has the largest probable rainfalls among 12 stations, whilst the smallest appears in the Tan Son Nhat station.

(4) Air Temperature

Air temperature in the Study Area is lowest in winter (December and January) and increases as season approaches into spring. On the other hand, air temperature reaches highest during the summer in the April/May period. It is observed that there is no significant difference in air temperature throughout a year. Furthermore, air temperature decreases with the increase in elevation. In Tan Son Hoa (El. 9 m), mean annual air temperature is found to be 27.4°C, whereas in Xuan Loc (El. 180m) 26.8°C, and in Bao Loc (El. 850 m) 21.7°C. While the daily data are not obtained, it is said that the air temperature difference in a day is approximately 7 to 8°C.

(5) Relative Humidity

Mean annual relative humidity in the Study Area varies in a range of 77.4 % at Tan Son Hoa climate station to 85.6 % at Bao Loc climate station. Relative humidity is high in the rainy season from June to October, reaching 85.8 %.

(6) Evaporation

Evaporation is measured by Piche in most of the climate stations in the Study Area except in Da Lat, Bao Loc, Lien Khuong, Phan Thiet and Tan Son Nhat Airport where evaporation measurement is obtained by pan. Seasonal variation shows that evaporation is high in the dry season, especially in March with a value of 162.8 mm per month. Maximum evaporation is measured at the Dong Xoai station with a mean monthly evaporation recording of 138.4 mm per month, however, it is noted that this data was only obtained through one-year observation. Meanwhile, a monthly evaporation of 121.1 mm is recorded at the Phan Thiet climate station.

(7) Sunshine Hours

In the Study Area, mean monthly sunshine hours vary from 5.4 hours in August to 9.1 hours in February with an average of 7.2 hours.

(8) Wind Velocity and Direction

The data obtained for the wind velocity and direction in the Study Area show that prevailing wind from South-West is formed through the rainy season during May to October by the high pressure in the Central Asia as noted previously. The obtained data also confirms that the North-East monsoon brings northern wind during the dry season from November to April.

4.2.3 Hydrology

(1) Available Data and Records

- Discharge data
  There are 15 discharge stations in the Study Area (refer to Figure 4.9). Using a rating curve developed for each station, observed water levels are converted to discharge.

- Water level data
  There are 23 water level stations mainly in the downstream reaches of the Dong Nai and Vam Co rivers where backwater by tidal effects is significant. These water level stations are established for the survey of salinity intrusion.

(2) Runoff

Mean annual runoff and specific discharge for the 15 discharge stations are computed by using collected monthly runoff data as shown below:

Station Name	Catchment Area (km^2)	Mean Annual Runoff (m^3/sec)	Specific Discharge (cms/km^2)
An Vien	264	7.6	0.0288
Can Dang	617	10.79	0.0175
Dai Nga	373	17.29	0.0464
Dau Tieng	2,700	57.7	0.0214
Dran	775	21.92	0.0283
Loc Ninh	500	11.63	0.0233
Luy	982	12.60	0.0123
Nha Trinh (before Da Nhim construction)	2,140	62.24	0.0291
Phu Dien	3,060	120.93	0.0395
Phuoc Hoa	5,765	217.07	0.0377
Phuoc Long	2,215	101.54	0.0458
Ta Lai (without Dran Catchment)	8850	299.08	0.0338
Ta Pao	2,000	75.78	0.0379
Thanh Binh	294	8.5	0.0289
Tri An (without Dran Catchment)	14,025	542.0	0.0386

Mean annual runoff observed in the basins of the Dong Nai River (both main stream and its tributaries; Dran, Ta Lai, Tri An and Thanh Binh) falls in a range of 0.0283 cms/km^2 at the upstream tributary, Dran, to 0.0386 cms/km^2 at Tri An in terms of specific discharge, while in the Be River basin, the specific discharge of mean annual runoff varies from 0.0377 cms/km^2 at Phuoc Hoa to 0.0458 cms/km^2 at Phuoc Long. In the La Nga River basin, the specific discharge ranges between 0.0379 cms/km^2 at Ta Pao and 0.0464 cms/km^2 at Dai Nga. In the Saigon River basin, it varies from 0.0214 cms/km^2 at Dau Tieng to 0.0233 cms/km^2 at Loc Ninh. The specific discharge of the East Vam Co River is found to be 0.0175 cms/km^2 at Can Dang.

(3) Data Scrutiny

Scrutiny of runoff data obtained at the 15 discharge stations in the Study Area is attempted by computing the runoff coefficient as shown below:

Station	Rainfall (mm)	Runoff Depth (mm)	Runoff Coefficient
An Vien	2,114.2	913.1	0.43
Can Dang	1,918.2	553.8	0.29
Dai Nga	2,558.1	1,469.9	0.57
Dau Tieng	2,038.7	650.3	0.32
Dran	1,767.2	895.2	0.51
Loc Ninh	1,987.1	736.0	0.37
Luy	1,486.8	406.9	0.27
Nha Trinh	1,334.3	921.1	0.69
Phu Dien	2,462.5	1,252.6	0.51
Phuoc Hoa	2,359.2	1,188.8	0.50
Phuoc Long	2,424.2	1,453.7	0.60
Ta Lai	2,385.2	1,070.4	0.45
Ta Pao	2,462.4	1,201.6	0.49
Thanh Binh	1,733.8	915.7	0.53
Tri An	2,388.5	1,218.0	0.51

In analyzing the above-obtained runoff coefficients, there is a tendency that the runoff coefficients of the East Vam Co River and Saigon River basins fall in a range of 0.29 at Can Dang to 0.37 at Loc Ninh. Similarly in the Dong Nai delta, runoff coefficients are found to be in a range of 0.43 at An Vien to 0.51 in Phu Dien. Runoff coefficients increase in the mountain area where annual rainfall is higher than the delta. In this mountain area, the runoff coefficients have a tendency to fall between 0.51 at Dran and 0.60 at Phuoc Long.

On the other hand, the runoff data at Nha Trinh can be judged to be less reliable due to the fact that the runoff coefficient of 0.69 at Nha Trinh is high when compared with the runoff coefficient of nearby stations (0.51 at Dran and 0.53 at Thanh Binh).

(4) Hydrological Measurement

As part of the verification of discharge data made available, intensive discharge measurements have been performed during the field work of Phase II in order to estimate the accuracy of existing water level versus discharge curve (H-Q curve) now being used at the selected discharge stations. As the results of hydrological measurements, no significant error is found in the rating curves currently used.

(5) Low Flow Study

The objective of the low flow study is to obtain daily runoff data at discharge stations for a continuous period of 30 years and to obtain a non-dimensionalized storage-draft curve at each discharge station. These daily discharge data are to be used later for the development and analysis of storage-draft curve at each damsite in the Study Area.

Runoff data at the discharge stations in the Study Area are not available for a continuous period of 30 years, but available for rainfall data. This situation encourages to predict 30-year continuous daily runoff data at a discharge station by applying a rainfall-runoff simulation

model. In this low flow study, Tank Model developed in Japan is used as the simulation model to predict 30-year continuous daily runoff data.

Based on the daily simulated runoff so obtained, estimated mean monthly runoff for each discharge station for the duration of 30 years is obtained. Storage-draft curves for those stations are developed as presented in the Appendix III. Furthermore, monthly runoff is prepared at the proposed damsites by multiplying the ratios of catchment area and mean annual rainfall.

(6) Flood Analysis

Flood analysis is carried out with two objectives; one is flood mitigation and the other is to estimate the design flood at the selected damsites. For the flood mitigation analysis, one of the distributed models, the storage-function model developed in Japan, is applied to predict design floods, whilst the design flood at the selected damsites is estimated by applying the Creager's formula.

Basic design flood discharge for the flood mitigation analysis is predicted by applying the estimated probable rainfall and the storage-function method as summarized below:

Basic Design Flood Discharge

Station	20-year flood(m^3/s)	100-year flood(m^3/s)
Ta Lai	4,904	6,558
Ta Pao	1,614	2,100
Phu Dien	995	1,235
Tri An	6,459	8,265
Phuoc Hoa	2,691	3,230
Dau Tieng	2,351	3,197

The spillway design discharge for the proposed dams is estimated by applying Creager's formula as follows:

Design Spillway Discharge			
Proposed dam	Basin area (km^2)	Creager's C	Design discharge (m^3/s)
(Dong Nai Main)			
Dong Nai No. 1	3,802	38	8,923
Dong Nai No. 2	3,943	38	9,050
Dong Nai No. 3	4,361	38	9,408
Dong Nai No. 4	4,530	38	9,545
Dong Nai No. 5	6,196	38	10,725
Dong Nai No. 6	7,051	38	11,237
Dong Nai No. 8	9,822	38	12,617
(La Nga River)			
Bao Loc	1,150	38	5,389
La Nga No. 3	2,000	38	6,873
(Be River)			
Can Don	3,440	25	5,645
Fu Mieng	4,410	25	6,216
Phuoc Hoa	5,765	25	6,872

(7) Sedimentation

A sediment analysis is made to estimate the long-term sediment loads which would be deposited in the reservoir. According to the collected sediment data, annual sediment load is estimated at 273,964 ton/year, resulting in a denudation rate of 0.114 mm/year.

Taking into consideration the fact that the denundation rate in the South-east Asia falls in a few millimeter a year, a denudation rate of 1.0 mm/year is used in this study as the guideline figure.

(8) Tides at the Saigon Port and Sea

Tides at the river mouth are an important factor for the studies of drainage and salinity intrusion problems, and thus tide data are collected at the Vung Tau port near the estuary of the Dong Nai River and at the Saigon port (Phu An Station) in the Saigon River.

Mean high (or low) water level (MHWL or MLWL), which is defined as an average of monthly highest (or lowest) tide levels in this study, varies seasonally. The MHWL at Vung Tau fluctuates for a range of 0.66 m seasonally from the maximum in December to the minimum in August, while the MHWL at the Saigon port varies for a range of 0.48 m. On the other hand, seasonal variation of MLWL has two peaks in March and September and bottoms in June/July and December with an annual difference of 0.64 m at Vung Tau and 0.82 m at Saigon port.

4.2.4 Installation and Measurements of Automatic Rainfall and Water Level Gauges

In order to improve the hydro-meteorological networks in the Dong Nai River and surrounding river basins, it was decided that during the Study period, three automatic water level gauges

and seven automatic rainfall gauges would be installed in the Study Area. During the first field work, efforts were concentrated for the selection of sites and installation of automatic gauges.

As a result of field work, following sites have been selected for the installation of new water level and rainfall gauges: (1) water level gauges: An Vien, Ta Lai and Ben Than and (2) rainfall gauges: Ngoc Son (Phu Son district People's Committee), Dai Ninh damsite, Song Luy gauging station, An Vien gauging station, Ben Than gauging station, Katum gauging station and Kien Duc gauging station (refer to Figure 4.10). Actual installation work was carried out over a time period of December 1994 to March 1995.

4.3 Physical Environments

4.3.1 Land Use

Present land use in the Study Area has been identified by the Sub-national Institute for Agricultural Planning and Projection (NIAPP) in HCMC based on satellite imagery of LANDSAT TM5 taken in February and March 1994 as summarized in Table 4.2.

Mekong delta in the Study Area covers about 5.5 % of the Study Area. Paddy field is the major land use in the Mekong area, occupying 56.8 % of the area. Canal network has well been developed for the irrigated paddy cultivation. Irrigated paddy area covers 50.8 % of the area. However, only about 42 % of the irrigated paddy area is under double and triple irrigation. Another noteworthy fact is that the double or single rainfed rice cropping is practiced in an area of 64,000 ha. The Mekong delta area has well been developed except for bare land which might be left behind from the development due to acid sulphate soil. It is noted that the word of Mekong delta in the Study Area is used for ecological discussions and that the word of HCMC-Long An delta is used for the same area when discussions are made for specific projects.

Southeast region in the Study Area is the largest area sharing about 48.3 % of the Study Area. About 53% of the area has been developed for agricultural production. Main land uses in the remaining areas are a forest of 24.29 % and a bare land of 14.94 %. About 18.5 % of the area is irrigated, of which only 3.82 % is double irrigated. Single irrigated rice fields extend for 160,750 ha. Rubber and paddy are the main crops in the area.

Central highlands in the Study Area covers 22.8 % of the Study Area. The area is mountainous with a forest coverage of 66 % and is one of the least developed areas in the country. Agricultural land is as little as 13.42 % of the area. Bare land occupies about 18.4 %

of the area. Irrigated area is 6.95 %, of which 1.71 % is currently used for double cropping of rice.

Coastal region in the Study Area covers 13.4 % of the total Study Area. Soil fertility is low with large extents of sandy soils and with an arid climate. Forests area covers 35.55 % of the area, followed by bush/grass area of 23.9 % and bare land of 16.89 %. Irrigated rice area occupies only 1.05 % of the area.

4.3.2 Soils and Land Suitability

According to the information from NIAPP, land in the Study Area has 36 soils grouped by the Vietnamese standard. Predominant soil in the Study Area is Yellow-red soil (Ferralitic soil) covering 47 % of the total area, followed by Grey soil of 21 % (refer to Table 4.3).

Land suitability for crop production in the Study Area is identified based on the information from the Sub-National Institute for Agricultural Planning and Projection. Land suitability classification criteria made by the Sub-Institute are discussed in Appendix VI in detail, and areal extents by the land suitability for irrigated paddy, rainfed paddy and perennial crops are shown in the following Table:

Land Suitability Classification for Crops

Suitability	HYV Paddy		Local Paddy, Upland Crops		Perennial Crops	
Unsuitable	4,376,530 ha	91 %	2,845,640 ha	59 %	2,484,610 ha	52 %
Highly suitable	157,640 ha	3 %	269,380 ha	6 %	0 ha	%
Moderately suitable	195,000 ha	4 %	1,524,360 ha	32 %	1,143,250 ha	24 %
Marginally suitable	93,120 ha	2 %	182,910 ha	4 %	1,194,430 ha	25 %
Total	4,822,290 ha	100 %	4,822,290 ha	100 %	4,822,290 ha	100 %

Remark: River, lake, city and town areas of 131,340 ha are excluded in the calculation.

Land suitable for paddy development is estimated at 9 % of the area, while at present 13.89 % of the area has already been developed for paddy areas. It can be said that almost all land suitable for paddy development has already been developed for paddy fields, and that there are over exploitation in the unsuitable areas for paddy fields such as in steep land, land on strong acid sulphate soils and sandy land.

Land suitable for upland crops is estimated at 42 % of the area. Land utilized for upland crops including fruit trees and plantation crops is 23.31 % of the area. Major parts of present paddy fields could be utilized for upland crops if drainage facilities are provided. So, 37.2 % of the area could have been used for upland crops. There is some potential for further development of land for upland crops, fruit trees and plantation crops.

Seven areas which have high potential for irrigation development were classified by present land use and land suitability for irrigation agriculture in the first home office work. The present land uses identified were revised based upon the ground checks. Land suitability maps prepared by Sub-NIAPP are too small in scale, 1:250,000, to identify potential for irrigation development by project-wise, so that the agricultural development expert made land suitability maps based on physiography, which was identified using 1:100,000 topographic maps. Land suitability criteria for irrigation development are shown in the following Table:

Land Suitability Criteria for Irrigation Agriculture

Land System	Land Form	Land Unit	Dominant Slopes	Dominant Slopes	Land Suitability	
					Paddy	Upland Crops
1	Alluvial plain	1a	Present river channel		B	B
		1b	Sand and gravel bars		B	B
		1c	Low terrace		A	A
		1d	Higher terrace		A	A
2	Alluvial fans or aprons	2a	Very gentle slopes		A	A
		2b	Gentle slopes	1-5°	A	A
		2c	Undulating	1-3°	A	A
		2d	Highly dissected	0-20°	B	A
3	Depositional basin or plateau	3a	Depression	< 0.5°	A	A
		3b	High position, non-dissected	< 2°	A	A
		3c	Gently rolling	1-5°	A	A
		3d	Highly dissected	0-30°	B	B
4	Mountain or hill	4a	Moderate to steep slopes	< 20°	B	A
		4b	Steep to very steep slopes	> 20°	B	B
5	Tidal swamp	5a			B	B

Remarks: A; Suitable, B; Unsuitable

Development areas in the individual schemes were classified according to the present land use and land suitability to irrigation development. The results are presented in Table 4.4, and further detailed results of this land suitability analysis are compiled in Data Book.

4.4 Natural Environment

4.4.1 Flora, Fauna and Biodiversity Values

(1) Perspective

Historically, Viet Nam was considered to have eight agro-ecological zones including the Northern Mountains; Northern Midlands (North Highlands and Midlands are divided into two); Red River Delta; North Central Highlands/Plateau; North-east of Southland and Mekong Delta (refer to Figure 2.1). Extensive parts of the upper catchment consisting of upper midland, highland and steep river valleys in the Study Area remain undisturbed, particularly in the Dong

Nai and Be River catchments. These are, to a large extent, the areas under the control of the Ministry of Agriculture and Rural Development and include Production, Protection and Special Use Forests.

Over 40 % of Vietnamese recorded 7,000 floral species are endemics, i.e. occurring only in Viet Nam, with further new endemic species considered likely also to occur; particularly in wetland ecosystems since these have not been fully sampled. The country's fauna is also diverse with over 270 mammals, 800 birds, 180 reptiles, 80 amphibians, 2,500 fish and invertebrates, i.e. 2000+ being marine species, and 5,500 insects having been identified. Considerable scientific interests exist in the country's flora and fauna particularly as a result of recent discoveries of new mammals, i.e. a small bovine (cattle like) animal (Vu Quang ox-*Pseudoryx spp.*) and a species of Giant Barking deer *(Muntiacus spp.)* in the highlands of central Viet Nam/Laos border area.

(2) Flora Resources Status and Use in the Study Area

As with other parts of Viet Nam, vegetation in the Study Area is diverse but residual areas rich in diversity and continuity are diminishing rapidly. This applies throughout the Study Area but particularly to the highland areas of the upper Dong Nai and Be River catchments. With over 7,000 plants and 1,400 species of epiphytes, fungi and periphytes identified, the potential exists for hundreds of flora species to occur in undisturbed areas such as the inaccessible riverine ecosystems.

Intrusions into remote areas for shifting cultivation, logging and exploitation of high quality woods, e.g. *Afzelia spp.* and *Sindora spp*, minor forest products, e.g. rattan, resins and natural fruit and medicinal plants are common in areas inhabited by minority ethnic groups, i.e. hilltribes such as Nung and Cho-ro in Dong Nai province, Xtieng in Song Be province and Lat and E-de in Dac Lac province.

Recent reports relating to required programmes for protecting the country's biodiversity indicate a serious lack of scientific data relating to wetland ecosystems, a diversity of which is associated with the rivers, reservoirs and estuaries in the Study Areas.

(3) Wildlife Habitat and Resources in the Study Area

The Study Area has a diversity of wildlife habitats ranging from undisturbed midland and upland primary forests to extensive grass and herbaceous scrub (barren areas) including some excellent inland and coastal wetlands. It is probable that virtually the complete range of main mammals as listed in Table 4.5 occurs somewhere in the Study Area, except possibly the endangered species Kouprey *(Bos sauveli)*.

(4) Aquatic Ecology and Fisheries in the Study Area

Basically, the river fish species are similar to those of the lower Mekong system with species distribution and productivity being controlled by river elevation and hence water temperature, flood regime and water quality. As elsewhere in Southeast Asia the main riverine and estuarine fish species would be dominated by the Cyprinids (Carps); Bagridae and Siluridae (Catfishes) and the universal predators Snakehead *(Ophiocephalus spp.)* in the river sections and Seabass *(Lates calicifer)* in the estuarine zones. Analyses of data available on fish distribution in the lower/central Mekong River Basin indicate Cyprinids to account for 35 to 45 % of species present (pers. data source).

(5) Aquatic Resources Industries and Development

Aquaculture is now the dominant source of fish and crustacean production, i.e. prawns and crabs, in the freshwater and estuarine waters of the Study Area. Grass, Silver, Bighead and Common Carp species are all raised using cage culture in Tri An and Dau Tieng reservoirs. Tiger prawns *(Penaeus monoclon)*, and White/Banana prawns *(P.indicus)* and some Seabass are raised in ponds in the estuarine zones. Most of these ponds are located southeast from Nha Be to Vung Tau in former mangrove areas converted to aquaculture ponds and are supplied from a modern prawn hatchery located near Vung Tau.

4.4.2 Forest Cover

The actual extent of forestry land altered to other land use purposes in recent years is difficult to ascertain but this is preliminarily indicated by the loss to deforestation. It is indicated that approximately 30 % of the forest cover of the Study Area was lost in the 1943 to 1991 period including over 24,000 ha or 11 % of the remaining forest cover in the 1973 to 1991 period. This is possibly an underestimate.

Extensive community and district forestry plantations have been developed by the various agencies of the Ministry of Agriculture and Rural Development and the People's Committees at various administrative levels. Communal agroforestry programmes are widespread throughout the lower and middle reaches of the Dong Nai River basin with excellent examples of mixed use of *Eucalyptus camadulensis* and *Acacia magnium* plantations including integrated use for pulpwood, firewood (thinnings and refuse), poles and charcoal, being evident in the immediate surroundings of the Dong Nai River and around of Tri An reservoir.

4.4.3 Protected Areas and Conservation Issues

As of the year 1992, there were 87 Protected Areas (PA) or Special Use Forests (SUF) covering about 3 % of Viet Nam's land area or about 993,000 ha. Recent assistance to the Ministry of Agriculture and Rural Development by conservation-oriented NGO's, particularly the IUCN, has recommended expansion and consolidation of Protected Areas into a more representative system covering Viet Nam's natural resource base and diversity and to include at least 2 million ha covering approximately 6 % of the country.

Wetland ecosystems in Viet Nam contain at least 30 genera of flora due to the presence of the Mekong Delta and inland riverine swamps and are indicated as having a greater biodiversity than those of other Southeast Asia ecosystems, e.g. Thailand (24 genera) and Philippines (19 genera). Of particular ecological and economic values are the *Melaleuca leucadendron* or "tram" forests (acid coastal and Mekong Delta swamps), coastal mangroves *(Rhizophora, ascilata* or "duoc", *Avicennia alba* or "nam quan" and *A.intermedia* or "nam den") and the tidal zone river fringing plant *Nipa fruticans* or "dua nuoc". Likewise there are several rare or endangered wildlife species associated with these wetlands.

A comprehensive system of Wetland Reserves has been proposed to the Ministry of Agriculture and Rural Development by the IUCN. This includes 10 wetlands including two lowland reservoirs (Tri An and Dau Tieng) and two highland reservoirs Da Nhim (Don Duong Lake) and Ankroet (Dan Kia Lake) in the Da Lat area.

5. NEEDS OF WATER RESOURCES DEVELOPMENT

5.1 General Background

Vietnamese economy enjoyed its high performance of more than 8 % in terms of the annual GDP growth rate in last a few years. The Government launched a medium-term economic development programme toward the year 2000, so-called "Socio-economic Stabilization and Development Strategy to the year 2000", in which economic development is targeted to sustain 7.5 % in the annual GDP growth rate. The World Bank predicts 6.0 % of GDP growth over a period of the year 1990 to 2010 as the most probable scenario.

The Southern Focal Economic Area (SFEA), which covers the main part of the Study Area, acts as a locomotive of economic development in the nation along with the Hanoi-Hai Phong area and the Da Nang area. This area covers the whole of Ho Chi Minh City, Dong Nai province and Ba Ria-Vung Tau province and a part of Song Be, Tay Ninh, Long An and Binh Thuan provinces with a land area of 12,400 km^2 and a population of 7.8 million. It includes the so-called "Economic Triangle Zone" that is formed by the three places of Ho Chi Minh City, Bien Hoa and Vung Tau and is emerging as a focal place of economic development in Viet Nam. According to the study made by the Ministry of Science, Technology and Environment, the expected GDP growth rate in the area up to the year 2010 is 12 to 13 %. Needs sought to the water resources sector for sustaining the economic development in SFEA including the Economic Triangle Zone are to supply electric power gained through the development of hydropower as well as domestic and industrial water.

The east coast area, covering Ninh Thuan and Binh Thuan provinces, is economically lagging behind from the other regions in the Study Area along with the central highland area. The area is fairly dry with less rainfall, and the coastal rivers are generally small in the catchment area, resulting in the limitedly available water resources. These conditions are impeding the expansion of irrigation schemes, and the extreme shortage of water in the dry season is causing the low cropping intensity in paddy cultivation.

Nevertheless, this area has the largest potential for the expansion of irrigation schemes in the Study Area. The total area of the potential irrigation schemes concentrated in this area is estimated at more than 40,000 ha. Available water in the area falls short of developing these potential schemes, and the possible measure to solve this problem is to divert water from the Dong Nai River basin to the coastal area. Full exploitation of the local water resources such as the Cai and Luy rivers is also required for this purpose.

There is an area called "HCMC-Long An Delta", which extends in the low-lying downstream reaches of the East Vam Co River and administratively belongs to Long An province and Ho Chi Minh City. Most of the HCMC-Long An Delta is short of irrigation water and suffers from

acid soil and salinity intrusion that takes place in the dry season, causing adverse effects to agriculture and people's daily life. A possible measure to improve this situation in the HCMC-Long An Delta is to introduce fresh water by water transfer from the Dong Nai River basin to this area.

Needs for water resources development in the Study Area including the discussions above are specified as follows:

a) Development of hydropower to cope with chronic shortfall of electric power in the southern Viet Nam, especially acute in the dry season,

b) Development of domestic and industrial water supply to secure healthy manpower and to sustain the economic development in the SFEA,

c) Agricultural development in the east coast area, where shortage of water is one of shackles in the expansion of the irrigation schemes,

d) Agricultural development in the low-lying HCMC-Long An Delta area, where fresh water is seriously lacking in the dry season for irrigation, acid flushing and salinity repulsion,

e) Development of the promising irrigation schemes in the areas other than the east coast and the HCMC-Long An Delta which are in the planning or potential status,

f) Exploitation of groundwater for water supply and agricultural development in the Study Area, and

g) Promotion of afforestation in the areas where deforestation to cause excessive soil erosion and sedimentation is progressing.

5.2 Hydroelectric Power Development

5.2.1 Present Situation of the Whole Country

The energy sector is substantially different in each of the three main regions of the country. In the north there is now an excess supply of hydropower along with the operations of coal-fired plants that are functioning at some 50 % of their capacity. The economy of the north has traditionally been coal-based and oriented towards heavy industry; it is growing relatively slowly compared to the southern region, and, in particular, the dynamic Ho Chi Minh City area. The central part of Viet Nam is generally less developed and less well-served by the electricity system; annual electricity consumption per capita is 52 kWh a year compared to 110 kWh a year in the north and the south. In terms of energy development, the southern

region is characterized by shortage of electricity generation, particularly in the dry season. In general, electricity consumption has been constrained by supply limitations in the south and centre.

The regional power supply characteristics in the year 1994 are summarized as follows:

Power Supply Characteristics in the Year 1994

Description	Northern PC1	Central PC3	Southern PC2	Viet Nam Total
Population (million)	33,204 (47)	10,458 (15)	26,275 (38)	69,938 (100)
Available Hydro Capacity (MW)	2,028 (72)	85 (3)	713 (25)	2,826 (100)
Available Thermal Capacity (MW)	652 (49)	115 (9)	558 (42)	1,325 (100)
Available Total Capacity (MW)	2,680 (65)	200 (4)	1,271 (31)	4,151 (100)
Energy Generation (GWh)	7,142 (59)	253 (2)	4,800 (39)	12,159 (100)
Energy Sales (GWh)	4,186 (49)	764 (8)	4,248 (43)	9,198 (100)
Peak Load in 1993 (MW)	1,076 (52)	190 (9)	817 (39)	2,083 (100)

Note: Figures in parentheses show percent shares in the whole of the nation.

Both the central and southern regions are presently importing electricity from the northern region with rather high system losses in a range of 20 to 25 % in the country.

5.2.2 Present Situation in the Study Area

In the southern region, the total power generation in the year 1993 was 4,667 GWh, of which 2,790 GWh (60 %) was generated by the hydropower plants and the remaining consists of 1,140 GWh (24 %) of oil-fired thermal, 716 GWh (15 %) of gas turbine and 126 GWh (2 %) of diesel.

The annual growth rate of power consumption during last 10 years was approximately 10 %. Major demand sectors are industrial sector (50 %) and residential (household/lighting) sector (36 %), followed by non-industrial (commercial/services) sector (10 %).