JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
MINISTRY OF AGRICULTURE, FORESTRY AND FISHERIES
KINGDOM OF CAMBODIA

THE AGRICULTURAL DEVELOPMENT STUDY OF THE MEKONG FLOODED AREA IN CAMBODIA

FINAL REPORT (APPENDICES)

MARCH, 1998

SANYU CONSULTANTS INC.

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MINISTRY OF AGRICULTURE, FORESTRY AND FISHERIES
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LIST OF APPENDICES

APPENDIX A

General

CONTENTS

A.1 Scope of Work

SCOPE OF WORK
FOR
THE AGRICULTURAL DEVELOPMENT STUDY
OF
THE MEKONG FLOODED AREA
IN
CAMBODIA

AGREED UPON BETWEEN

THE ROYAL GOVERNMENT
OF
CAMBODIA
AND
JAPAN INTERNATIONAL COOPERATION AGENCY

Phnom Penh, October 26, 1995

HE Mr Chhea Song
Secretary of State,
Ministry of Agriculture, Forestry and Fisheries
Royal Government of Cambodia

Mr Yuji Sakamoto
Leader,
Preparatory Study Team
Japan International Cooperation Agency

I. INTRODUCTION

In response to the request of the Royal Government of Cambodia(hereinafter referred to as "RGC"), the Government of Japan has decided to conduct the Agricultural Development Study of Mekong flooded area in Cambodia (hereinafter referred to as "the Study") in accordance with the relevant laws and regulations in force in Japan.

Accordingly, Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, will undertake the Study in close cooperation with the authorities concerned of RGC.

The present document sets forth the Scope of Work with regard to the Study mentioned above.

II. OBJECTIVES OF THE STUDY

The objectives of the study are :

1. To make an agricultural development plan of Mekong flooded area in Cambodia, and
2. To transfer technology to the Cambodian counterpart personnel through on-the-job training in the course of the study.

III. STUDY AREA

The Study covers Mekong flooded area in Kratie province, Kompong Cham province, Prey Veng province, Kandal province and Takeo province, which is approximately 600,000ha.

IV. SCOPE OF THE STUDY

Phase I (Master plan study)

1. Collection and review of the existing reports, data and information on the following items and field survey
   a. Natural conditions
   b. Social conditions

c. Agriculture, livestock and fisheries

d. Agricultural infrastructure

e. Agro-economy

f. Social infrastructure

g. Environmental aspects

2. The Study for the good solution of two sectors, agriculture and fisheries for the co-prosperity in the same project area

3. Interview survey for farmers

4. Evaluation of flood / inundation influences, available water and land and existing farming practices.

5. Review of relevant development plan and projects in the Study area.

6. Formulation of the master plan for agricultural development plan including identification of priority project(s).

Phase II (Feasibility Study)

1. Collection of data and information in the selected project areas through additional field survey.

2. Formulation of agricultural development plan in each project area which includes the following:

a. Land use plan, farming plan and agricultural supporting system

b. Preliminary design of infrastructures

c. Implementation schedule

d. Estimation of the project costs and benefits

e. Evaluation of the project

f. Recommendation

V. STUDY SCHEDULE

The Study will be carried out in accordance with the attached tentative work schedule as

ANNEX I.

VI. REPORTS

JICA shall prepare and submit the following reports in English to RGC.

1. Inception Report

   Twenty(20)copies in English at the commencement of the Phase I study.

2. Progress Report(1)

   Twenty(20)copies in English at the end of the field work of Phase I study.

3. Interim Report

   Twenty(20)copies in English at the commencement of the Phase II study.

4. Progress Report(2)

   Twenty(20)copies in English at the end of the field work of the Phase II study.

5. Draft Final Report

   Twenty(20)copies in English at the end of the Second home office work.The Cambodian side provides JICA with its comments on the Draft Final Report within one(1) month after receipt of the Draft Final Report.

6. Final Report

   Fifty(50) copies in English within one(1) month after receiving RGC's comments on the Draft Final Report

VII. UNDERTAKING OF RGC

1. To facilitate the smooth conduct of the Study, RGC shall take necessary measures:

   (1)To secure the safety of the Japanese study team.

   (2)To permit the members of the Japanese study team to enter, leave and sojourn in Kingdom of Cambodia for the duration of their assignment therein, and exempt them from foreign registration requirements and consular fees.

   (3)To exempt the members of the Japanese study team from taxes, duties and other charges on equipment, machinery and other materials brought into and out of Kingdom of Cambodia for

the conduct of the Study.

(4)To exempt the members of the Japanese study team from income taxes and charges of any kind imposed on or in connection with any emoluments or allowances paid to the members of the Japanese study team for their services in connection with the implementation of the Study.

(5)To provide the necessary facilities to the Japanese study team for remittance as well as utilization of the funds introduced into Kingdom of Cambodia from Japan in connection with the implementation of the Study.

(6)To secure permission for entry into private properties and other areas for the conduct of the study when necessity arises.

(7)To secure permission for the Japanese study team to take copies of all data, documents including photographs, (excluding restricted material) related to the Study out of Kingdom of Cambodia to Japan.

(8)To provide medical services as needed and its expenses will be chargeable on the members of the Japanese study team.

2. RGC shall bear claims, if any arises, against the members of the Japanese study team resulting from, occurring in the course of, or otherwise connected with, the discharge of their duties in the implementation of the Study, except when such claims arise from gross negligence or willful misconduct on the part of the members of the Japanese study team.

3. Ministry of Agriculture, Forestry and Fisheries has all responsibilities for the implementation of the Study and also as coordinating body in relation with other governmental and non-governmental organizations concerned for the smooth implementation of the Study.

General Department of Agricultural Hydraulic and Hydro-Meteorology, Ministry of Agriculture, Forestry and Fisheries shall act as counterpart agency to the Japanese study team.

4. Ministry of Agriculture, Forestry and Fisheries shall, at its own expense, provide the Japanese study team with the followings, in cooperation with other relevant organizations:

(1)Available data and information related to the Study, including 1/25,000 aero photos and

1/50,000 topographic maps

(2)Counterpart personnel,

(3)Credentials or identification cards,

(4)Suitable office space with necessary equipment in Phnom Penh and survey site, and

(5)Vehicles with drivers and necessary equipment for the Study.

VIII. UNDERTAKING OF JICA

For the implementation of the Study, JICA shall take the following measures;

(1)To dispatch, at its own expense, the Japanese study team to the Kingdom of Cambodia.

(2)To perform technology transfer to the Cambodian counterpart personnel in the course of the Study.

(3)Soil survey and Point elevation survey, when necessary

IX. CONSULTATION

JICA and RGC shall consult with each other in respect of any matter that any arise from or in connection with the Study.

ANNEX III

TENTATIVE WORK SCHEDULE

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Work in Cambodia																					
Home office work in Japan																					
	△ Ic / R								△ P / R(1)			△ It/ R				△ P/ R(2)		△ Df/ R			△ F / R

(Remarks)

Ic / R	: Inception Report
P / R(1)	: Progress Report(1)
It / R	: Interim Report
P / R(2)	: Progress Report(2)
Df / R	: Draft Final Report
F / R	: Final Report
◎	: Comments on DF /R by the Cambodian side

A.2 Minutes of Meeting

MINUTES OF MEETING
ON
SCOPE OF WORK
FOR
THE AGRICULTURAL DEVELOPMENT STUDY
OF
THE MEKONG FLOODED AREA
IN
KINGDOM OF CAMBODIA

The Preparatory Study Team (hereinafter referred to as "the Team") organized by the Japan International Cooperation Agency (hereinafter referred to as "JICA"), headed by Mr Yuji Sakamoto, visited the Kingdom of Cambodia from October 6th to 29th, 1995 for the purpose of discussing and confirming the Scope of Work for the Agricultural Development Study of the Mekong Flooded Area in Kingdom of Cambodia (hereinafter referred to as "the Study").

The Team had a series of discussions with the officers concerned of General Department of Agricultural Hydraulic and Hydro-Meteorology, Ministry of Agriculture, Forestry and Fisheries(hereinafter referred to as "GDH") and other organizations concerned. The list of participants in a series of meetings is attached in the Annex 1.

As a result of the discussions, GDH and the Team agreed on Scope of Work for the Study.

The following are the main issues discussed and agreed upon by both sides in relation to the Scope of Work for the Study.

1. The team submitted the field report dated Oct. 25'95 and both sides exchanged views on the basic concept of the study mentioned in paragraph 8 "Direction of the Study" in the report.
   As a result of the discussion, Cambodian side accepted the basic concept of the study.

2. In order to smoothly conduct the study, both sides recognized necessity of

formulation of the steering committee as a coordination body of Cambodian side. the details and the member shall be decided upon arrival of Master Plan Study Team.

3. Cambodian side basically agreed upon Paragraph VII "UNDERTAKING OF RGC"in the Scope of Work, nevertheless Cambodian side commented that there might be difficulty in provision of sufficient facilities such as office equipment, vehicles and etc.

4. The Master Plan Study Team shall exclude a part of the study area from the study, wherever security problems arise.

Phnom Penh, October 26, 1995

HE Mr Chann Saphan
Under Secretary of State,
Ministry of Agriculture ,Forestry and Fisheries

Yuji Sakamoto
Leader,
Preparatory Study Team
Japan International Cooperation Agency

ANNEX 1

LIST OF PARTICIPANTS

Ministry of Agriculture ,Forestry and Fisheries

HE Mr Chhann Saphan	Under Secretary of State, MAFF
HE Mr Sin Niny	Director General, MAFF and Permanent Secretary of Cambodian National Mekong Committee
Ms Soy Bora	International Cooperation Office, dept. Plan, MAFF

General Department of Agricultural Hydraulic and Hydro-Meteorology, MAFF

Mr Lim Kean Hor	General Director, General Department of Agricultural Hydraulic and Hydro-Meteorology, MAFF
Mr Veng Sakhon	Deputy Director General, General Department of Agricultural Hydraulic and Hydro-Meteorology, MAFF
Mr Bun Hean	Design Office Chief, General Department of Agricultural Hydraulic and Hydro-Meteorology, MAFF
Mr Takashi Kawai	JICA Expert

Department of Fisheries, MAFF

Mr Ouk Sim	Deputy Director, Fisheries Department
Mr Phoeun Phean	Vice Head of Open Water

Council for Development of Cambodia

Ms. Heng Sokun	Coordinator of Japanese Assistance
Mr Tetsuro Hamada	JICA Expert

Ministry of Environment

Ms. Hok Sovann	Vice Director, Department of Planning

Ministry of Republic Work

Mr Phung Katry	Director of Department of hydrology, Major Dam, Ministry of Public Work

Cambodian National Mekong Committee

Mr Sin Niny	as mentioned above

Embassy of Japan

Mr. Shigemitsu Tsukamoto	Second Secretary

JICA Cambodia Office

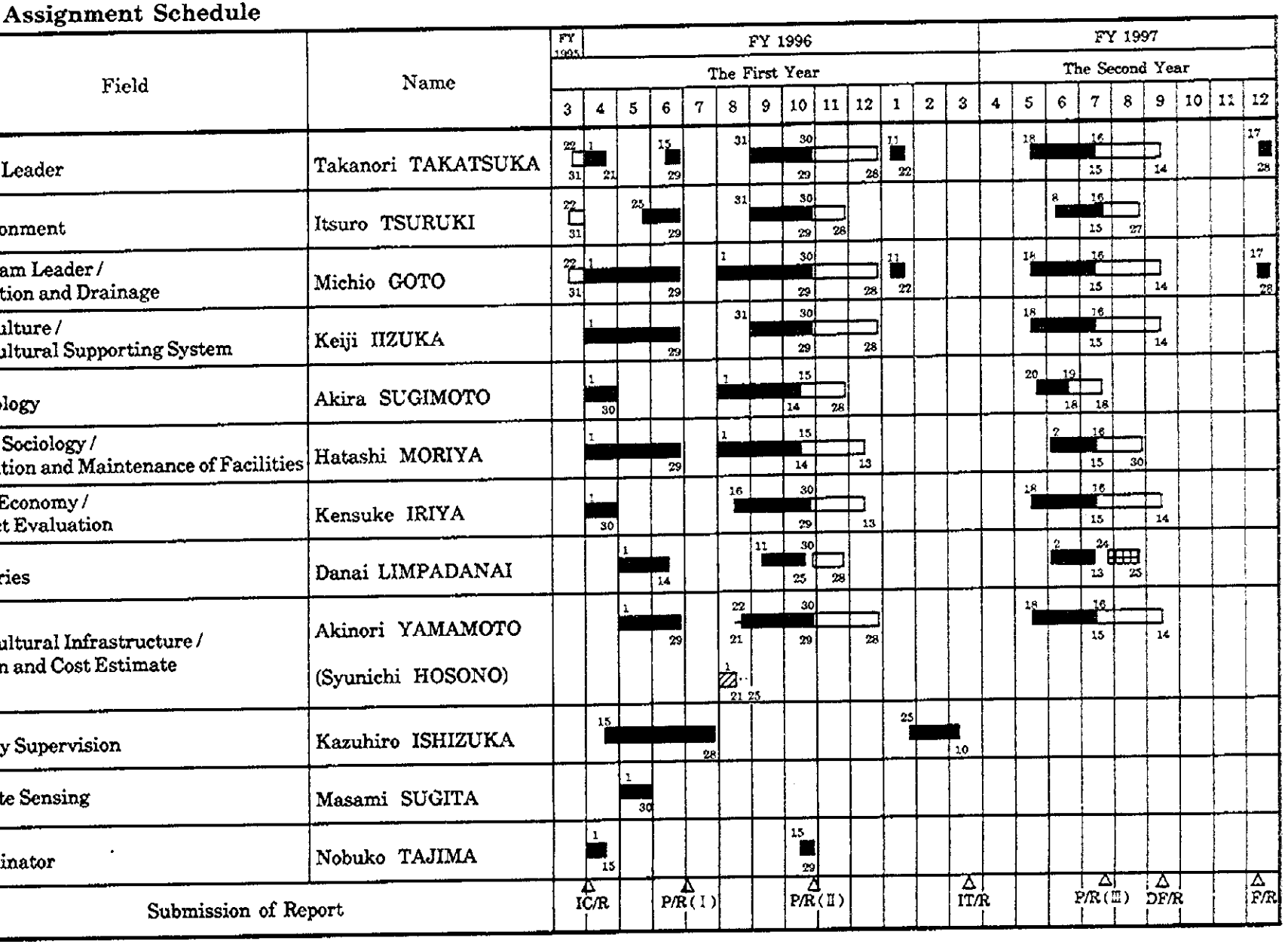
Mr Koji Sakane	Staff

The Team

Mr Yuji Sakamoto	Leader
Mr Akira Ara	Member
Mr Hideaki Tanaka	Member
Mr Takenobu Suzuki	Member
Mr Kariyan Mei	Member
Mr Mineo Kai	Member
Mr Masaki Óga	Member

A.3 Assignment Schedule

Field	Name
Team Leader	Takanori TAKATSUKA
Environment	Itsuro TSURUKI
Co-Team Leader / Irrigation and Drainage	Michio GOTO
Agriculture / Agricultural Supporting System	Keiji IIZUKA
Hydrology	Akira SUGIMOTO
Rural Sociology / Operation and Maintenance of Facilities	Hatashi MORIYA
Agro-Economy / Project Evaluation	Kensuke IRIYA
Fisheries	Danai LIMPADANAI
Agricultural Infrastructure / Design and Cost Estimate	Akinori YAMAMOTO (Syunichi HOSONO)
Survey Supervision	Kazuhiro ISHIZUKA
Remote Sensing	Masami SUGITA
Coordinator	Nobuko TAJIMA
Submission of Report	



LEGEND: Field Work; Home Office Work; Hosono's execution; Work in Thailand

IC/R : Inception Report
P/R(Ⅰ),(Ⅱ),(Ⅲ) : Progress Report(Ⅰ),(Ⅱ),(Ⅲ)
IT/R : Interim Report
DF/R : Draft Final Report
F/R : Final Report

A.4 List of Members Related for the Study

A.4.1 Member of the Study Team

Mr. Takanori TAKATSUKA	Team Leader
Mr. Itsuro TSURUKI	Environment
Mr. Michio GOTO	Deputy Team Leader/ Irrigation and Drainage
Mr. Keiji HZUKA	Agriculture/ Agricultural Supporting System
Mr. Akira SUGIMOTO	Hydrology
Mr. Hatashi MORIYA	Rural Sociology/ Operation and Maintenance Facilities
Mr. Kensuke IRIYA	Agro-Economy/ Project Evaluation
Mr. Danai LIMPADANAI	Fisheries
Mr. Akinori YAMAMOTO	Agricultural Infrastructure/ Design and Cost Estimate
Mr. Kazuhiro ISHIZUKA	Survey Supervision
Mr. Masami SUGITA	Remote Sensing
Miss, Nobuko TAJIMA	Project Coordinator

A.4.2 Name of Counterpart Personnel

Mr.Chea Pagnarith	Environment, Department of Planning and Water Management of the Ministry of Environment
Mr.Dok Doma	Irrigation and Drainage, General Department of Irrigation, Meteorology and Hydrology ,(GDIMH)
Mr.SaoChesda	Agriculture/Agricultura Supporting System Department of Agronomy, MAFF
Mr. Te Navuth	Hydrology, GDMIH
Mr. Tuot Lux	Rural Sociology/O&M of Facilities, Trainning Office, Ministry of Rural Development
Miss.Suong Chantha	Agro-Economy/ Project Evaluation, Departmentof Agronomy, MAFF
Mr.Heng Sotharihe	Fisheries, Department of Fisheries, MAFF
Mr.Meas Dara	Agricultural Infrastructure/Design and Cost Estimate, GDIMH
Mr.Tan Eth	Survey Supervision, GDIMH

A.4.3 Related Agencies and Personnel

(1) Ministry of Agriculture Forestry and Fishery (MAFF)

Mr.Chang Ton Yves	Under Secretary
Mr. Hean Bun Theav	Chief of Planning and Accounting

1) GDIMH

Mr. Veng Sakon	Deputy Director General
Mr. Bun Hean	Chief of Design Office
Mr. Se Samouth	Chief Construction Office
Miss. Kong Vutheary	Water Quality Laboratory
Mr.Seth Vannareth	Chief of Cambodia Meteorological National Services (CMNS)

2) Department of Agronomy

Mr. Chia Nam	Director
Mr. Has Sok	Vice-Director
Mr. Suon Chantha	Agro-Economist
Mr. Soun Dararith	International Relation Section
Mr. Sieng Borin	Chief of Soil Laboratory

3) Department of Forestry

Mr.Sokhun Ty	Deputy Director of FMO National-P-Coordinator

4) Department of Planning, Statistic and International Cooperation

Mr. Leng Sophal	Chief Office, International Cooperation

5) Department of Fisheries

Mr. Ouk Sim	Vice Director
Mr.Ham Meth	Chief of Exploitation Officer
Mr. Un Ay	Chief of Inspection Officer
Mr. Long Chheany	Chief of Planning and Accounting
Mr. Touch Seang Tana	Fishery Advisor, Project Director

(2) Ministry of Planning

Mr. Hou Taing Eng	Director, National Institute of Statistics
Mr. Khieu Sary	Deputy Director, National Institute of Statistics
Ms. Natalin Cagawan	Team Leader, Statistical System Development Project, ADB, Institute of Statistic

(3) Ministry of Industry , Mines and Energy

Mr Peng Navuth	Economist, Deputy Chief of Small Industry and Handicraft Bureou
Mr. Ho Vichit	Director, Technical Department

(4) Ministry of Environment

Dr. Um Bunna	Director of Planning & Legal Affairs
Mr.Pum Vicheth	Deputy Director of Department of National Park & Environment Data Management
Mr. Chay Sameth	Deputy Director of Department of National Park & Protected Area System Management

(5) Ministry of Rural Development

Mr. Ngy Chanphal	Under Secretary
Mr. Ouk Dara	Director of Water and Sanitation. Department of Rural Development

(6) Ministry of Council

Mr. Huon Savang	Director, Department of Geographic Department
Mr.Chin Van	Chief of Administration, Department of Land Title

(7) Mekong River Commission

Mr Kazunori Oshima	Senior Project Officer, Water Resources and Hydropower Unit, Secretariat
Mr. Thevet Insisiengmay	Director, Technical Support Division

(8) National Mekong Committee

Mr. Ing Klet	Chairman
Mr. Pich Dun	Irrigation Engineer

(9) IMF

Mr Namoch Sokhom	Assistant to the resident representative

(10) UNDP

Miss. Yuka Makino	Programme Officer

(11) NGO

1) SAWA Cambodia	Mr. Foort Bustraan, Rural Water Supply Team Leader
2) AICF	Action Internation Contre le Faim (AICF) Mr. Ludovec Bourde, Country Representative
3) Miss.Aiko Nishi	Coordinator, Social Welfare Programme, Japan International Volunteer Center

(12) Cambodian Mine Action Center

Mr. Mao Vanna	Chief of Information

(13) Rural Development and Resettlement Project

Mr.Takeo Fujita	Project Manager, JICA Expert
Mr.Yukiya Saito	Assistant Project Manager, JICE

(14) JICA Expert

Mr.Yuto Hara	Agronomist, Department of Agronomy, MAFF
Mr.Takashi Kawai	Irrigation Engineer, GDIMH
Mr.Tesuro Hamada	Council for Development of Cambodia(CDC), Cambodia Rehabilitation and Development Board

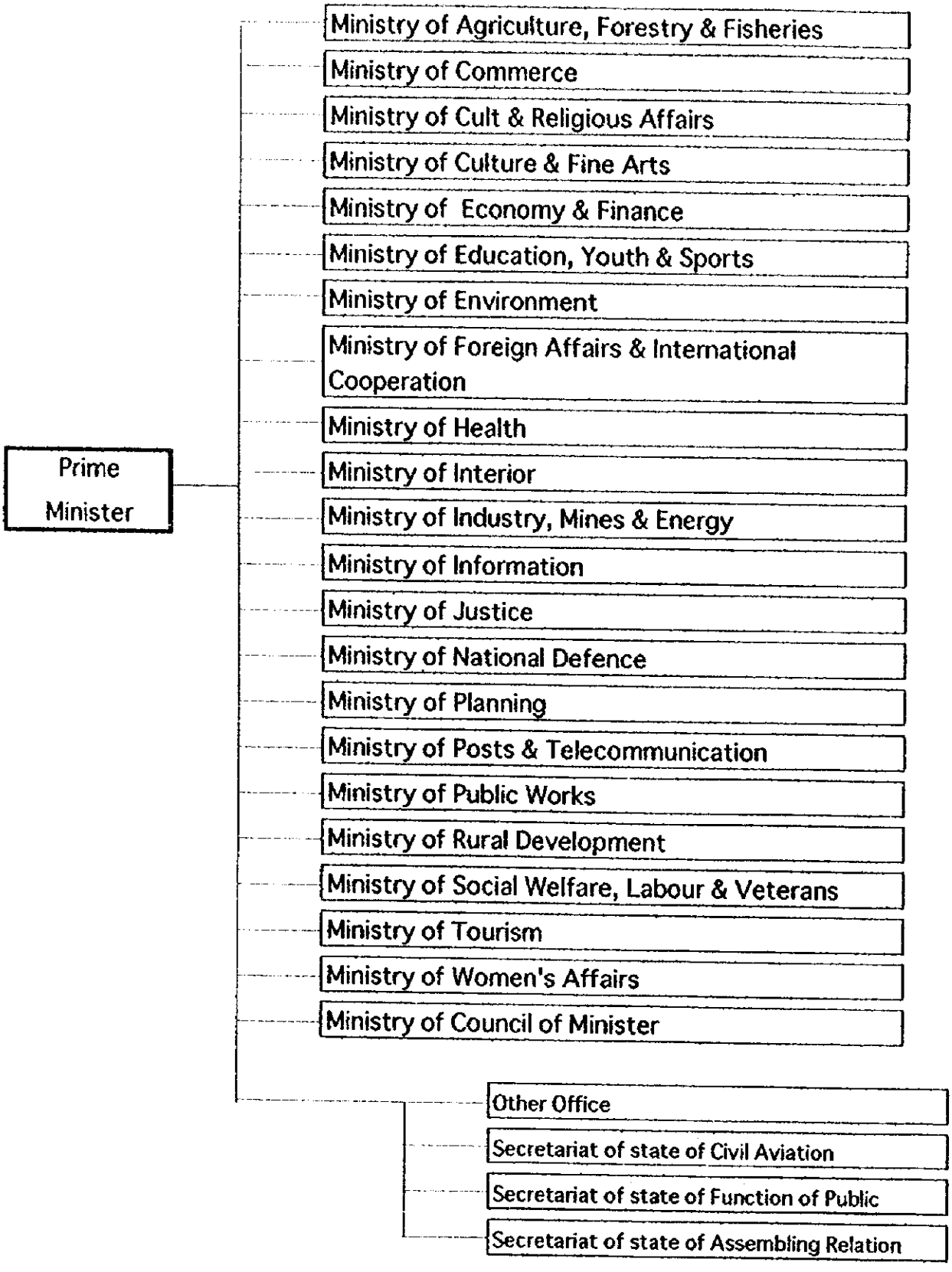
(15) JICA Cambodia Office

Mr.Hiroyuki Arai	Resident Representative
Mr.Koji Sakane	Assistant Resident Representative

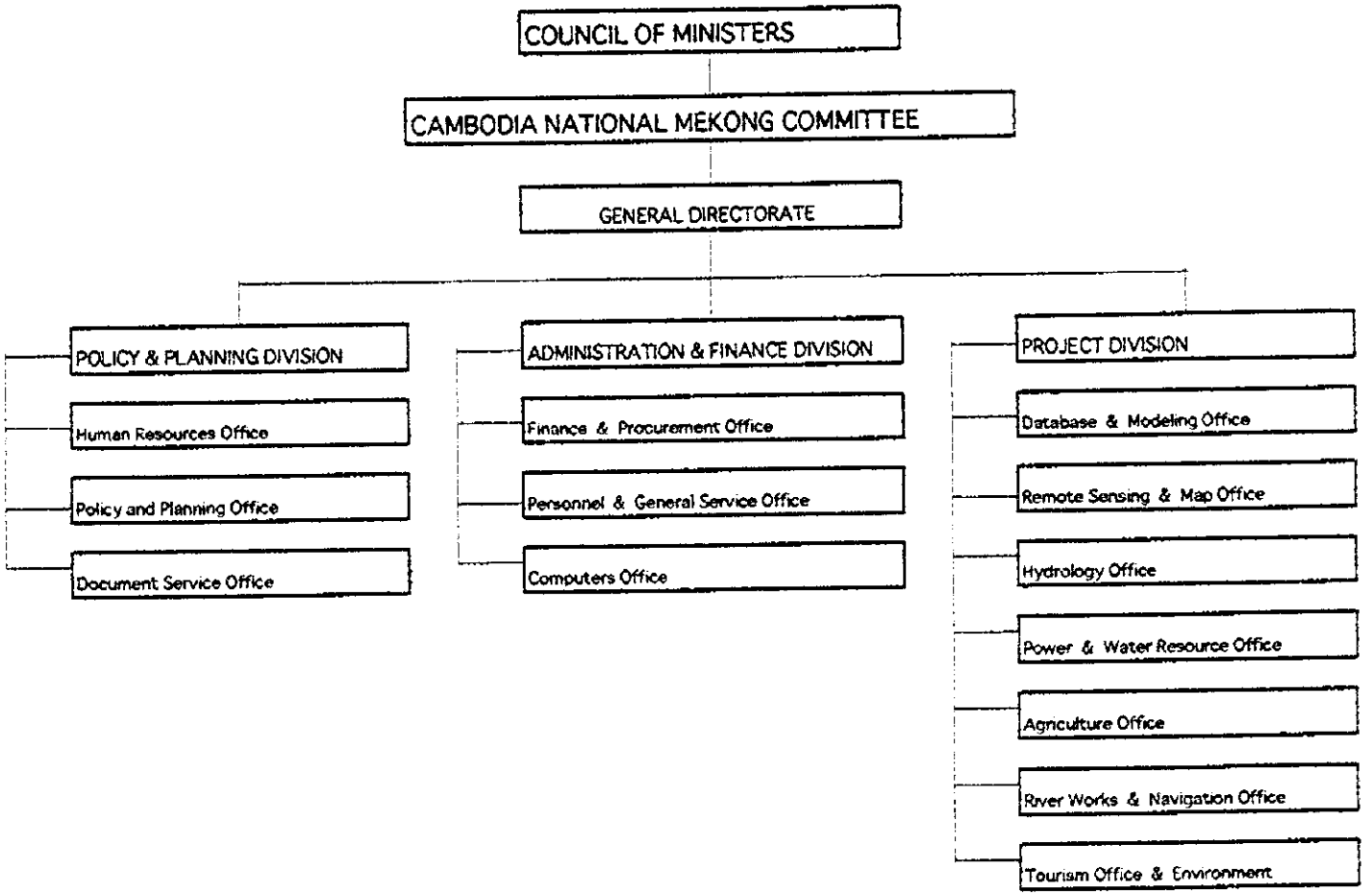
(16) Embassy of Japan

Mr.Shouhei Naito	Ambassador
Mr.Shigenobu Kato	Minister-Counsellor
Mr.Masato Iso	First Secretary
Mr.Shigemitu Tsukamoto	First Secretary

A.5 National Administrative Organization



A.6 Organization Chart of the Cambodia National Mekong Committee



APPENDIX B

Environment

Contents

B. Environment

B.1 Introduction

B.1.1 Background

Agriculture is the most important sector in Cambodia. It contributes to 45 percent of GDP in 1995, growing at 2.6 percent annual rate between 1990 and 1995, slightly below the rate of population growth. Most of the population is predominantly dependent on agriculture, particularly rice cultivation, for their livelihood and sustenance. Although 85~90 percent of the cultivated area is under rice, many households fail to produce enough rice to meet their needs, or to earn sufficient income in other ways.

The basic goals of the Government in the agricultural sector are to ;

- ensure food security through expansion of rice production, and its availability in the market, and of secondary food crops,
- contribute to economic growth and to foreign earnings through exports, and
- improve income opportunities for farm households by diversifying crop production.

The primary purpose of agriculture is to stabilize rice output through water harvesting. It is clear that the paddy yields in reliably irrigated areas are higher than under rainfed condition. Most of the rice will continue to be grown in the rainfed ecosystem. However, irrigated rice cultivation is making an important contribution to the livelihoods of a significant proportion of farmers. The poorest segment of rural population will become highly dependent on rice for food, having less surplus to sell for cash. The effective way of improving their food supply is to increase fields rather than to increase the cultivated areas. To reduce periodic major yield losses and to diversify agricultural and pursuing other sources of income will come next.

It is difficulty to exploit or to extend new lands for agriculture, because most of the cultivable lands in the study area have already been developed. It is seen that the ecological circumstances have been changing, except for some wetlands and swamps, and the remaining forests are threatened by encroachment of farmlands and firewood extraction in the study area.

In years when mid-season drought is severe, irrigation is vital for agriculture. Many of the irrigation systems are required to restore their effective function, lost during the past decades due to the civil conflicts and lack of maintenance. The priority in agricultural development should be given to the rehabilitation of existing irrigation systems rather than to construction of new ones.

The farmlands are expected to be used efficiently by introducing intensive farming with proper water control and cropping diversity. Rehabilitation of irrigation systems is one of the ways to increase agricultural production and income generation. Rehabilitative projects in this Master Plan (M/P) will be formulated taking account of environmental situation to minimize negative impacts.

B.1.2 Outline of the M/P

B.1.2.1 Rehabilitation Requirement

With above condition, rehabilitation projects are required to be implemented urgently to maintain farming and fishing activities, as the following;

- Regulating facilities with manual gates should be provided at inlets of existing canals to assure in and out flow control for the benefits of farmers and fishermen.
- Canals should be restored to ensure passage of silt-rich-water into the flooded field.

B.1.2.2 Objectives of the M/P

Objectives of the M/P are summarized as follows:

- To maintain agriculture and fishery production ground through stable supply of water rich in sediment.
- To preserve the ecosystem in and around the inundated forests and swamp areas through maintaining the hydrological cycle of flooding.
- To restrict undesirable encroachment of farms into swamp areas, by alternating to efficient use of existing farmlands and seasonal fallow lands.

B.1.2.3 The M/P Component

The M/P consists of the following components,

- Rehabilitation of water control gates, culverts with gates and bridges.
- Dredging of canals and repairing of the eroded banks.
- Provision of portable pumps.
- Reinforcement of dikes and reservoirs.

This report outlines the main points on the state of environmental conservation in the study area and summarises the environmental aspects of the component of the M/P.

B.2 Existing Environmental Conservation

B.2.1 Environmental Conservation in the Flood Plain

The Mekong river provides a broad range of benefits, both at national and community level. The river harbors a variety of fishes which exploit the rich nutrients found in the waters. It also supplies domestic and irrigation water and provides an important transport medium. And the river basin plays an important role in flood control and discharge regulation. The main threats to the river basin are siltation, water impoundment, water pollution, over exploitation of fish, and clearing the riverine and floodplain of vegetation.

The Mekong river exhibits pronounced annual variation in discharge. The discharge, and hence water level, in Mekong and Bassac river starts to increase in late May due to melted snow in the north and monsoonal rains. During that time, the Mekong river pushes back enormous amount of water to the Great Lake through the Tonle Sap river and into the floodplains through the tributaries and the many colmatage canals along the rivers. When the water level of the Great Lake reaches the highest, the Great Lake starts to discharge its engorged water to the Tonle Sap river in September or October. As a result, the inundated areas along the Mekong and Bassac river expand to their maximum and are covered for 4 to 7 months. By the end of April, many of the water bodies become isolated and the smaller tributaries including colmatage canals will dry up.

Inundation is the most important factor influencing the productivity of rice cultivation and fishery. The Mekong river provides abundant water, rich in sediment and organism. Floating rice and recession rice benefit from the annual siltation which has high potential in term of productivity improvement. In some areas, water bodies including reservoirs fed by annual inundation are available for irrigation.

Inundated zones serve for the bulk of the fish as spawning, breeding and feeding grounds. The flood water brings suspended and dissolved solids into the floodplain, releasing a high organic content from the soil, vegetation and inundated organic debris. It is an important factor in the potential productivity of the inland fishery. The hydrological cycle of the Mekong river induces the seasonal migration and reproduction of most fish.

On the other hand, exceptional high flood of the Mekong river causes extensive physical and economic damage to the region, by cutting off main routes, submerging rural roads for months, damaging bridges, isolating villages and washing away crops. This usually leads to food shortage, particularly rice, in the flooded area. While controls of floods is difficult, it is clear that mitigating measures and checking flood spread are required to ensure the

expected economic growth of the country.

Rainfed lowland rice is concentrated in the flood plains along the Mekong and Bassac river, like in the surrounding of the Tonle Sap Lake. Rice production in the study area is over 40% of that of the whole country, and 80% of rice is under rainfed lowland rice. Along the banks of the Mekong and Bassac river in Kandal, and some parts of Takeo and Kampong Cham, diversified farming system, maize, sesame, sugarcane, vegetable and fruits, is practiced. Production of maize in Kandal is 50% of the country. Agricultural output is strongly affected by seasonalchange in weather, in particular by drought and floods. Irrigation plays a very important role in rice production. Areas which can be irrigated in the dry season are limited, and supplementary irrigation of wet season crops has to involve diversion and/or water retaining structures.

Increasing food demand particularly by urban population growth requires a more sufficient and diversified agricultural production. Since exploitation of new farmlands to meet increasing demand is difficult, the existing farmlands should be utilized more efficiently. The necessities for crop intensification are irrigation, proper application of fertilizers and agrochemicals, high yield varieties and proper management skills supported by technical extension service.

Crop intensification has been proposed as an effective means of achieving food production increase. Intensive farming is a popular practice in colmatage farming areas of Kandal province. Intensive farming will involve the application of fertilizer and agrochemical, and it is attractive to farmers expecting higher yield from limited lands. It has been observed that fertilizer and agrochemical use in Cambodia is still small compared to other countries in the region. However, intensive farming will prompt farmers to use fertilizers and agrochemicals indiscriminately, unless a proper guidance is provided to them.Some farmers have used pesticides in WHO class I a and I b. Information and data on the use of these chemicals are not available. MAFF is currently drafting regulations and guidelines on the application of fertilizer and pesticide. Under the above condition, a coherent system for monitoring survey of the usage, analysis and feedback to the field is required for to environmental management in the very near future.

Cattle generally contribute significantly to rural development, through providing almost all draught power for cultivation, haulage of farm produce, and manure to improve soil fertility. However, the productivity of livestock is low due to lack of effective veterinery service for disease control and poor infrastructure for feed supply and other needs.

While the fishery sector makes a small contribution, in total about 4% Of GDP in 1995, next to rice, fish is the staple protein in the diet. Over 200 fish species inhabit the inland waters, most of which are captured for food. The inland fishery is governed completely by the annual hydrological cycle of the Mekong river. The inland fishery is exploited at three levels, family fishing, artisanal small scale fishing and industrial fishing. The family fishing is not regulated and is permitted all year round. The small scale fishing takes placeoutside the fishing lots and fish are sold in local markets. The industrial fishing is practiced in auctioned lots during limited season. Criteria for fish grading are based on fish size and species. Valuable species are becoming scarce, and small fish grade is becoming the majority of catch. The changes in fish catch could be the result of uncontrolled intensive fishing. It may lead to reduction in catch of some large-sized fish species. Several proposals have been made to rehabilitate some of the fresh water fisheries such as reforestation of flooded forests, dredging of colmatage canals and development of reservoir fishery and aquaculture. Moreover, efforts to increase fish production are supported by the World Bank and by NGOs, for fish breeding and extension service.

Firewood is still the main source of fuel for domestic cooking and commercial kilns in the study area. Fuel sources have to be extracted from scarce forests and shrubs. Most of the rural families gather firewoods for their own use and sell locally whenever possible. Many rural people can resort to alternatives such as dung sticks, leaf stems, rice husk, and even straw when firewood is expensive and locally scarce. As one of the measures to improve the situation, MOE introduced a report which investigated firewood demand for domestic cooking in Prey Veng, and presented an economic analysis of improved stoves which use 20~25% firewood less than traditional stoves commonly used throughout the country, in 1995.

It is reported that many forests have been cut in Prey Veng, Takeo and Kandal for several decades. The forest is accounted for 79% of the total land in Kratie, 29% in Kompong Cham, 20% in Kandal, 7% in Takeo, and 3% in Prey Veng, according to Land cover Atlas in Cambodia in 1992/93 (Table B.2.1). Since cultivable lands are dominant in the floodplains, except in Kratie, there are many difficulties on the reforestation. However, it is clear that unless actions are taken, paying special attention to recommendations and proposals by UNDP and other cooperating organizations, forests will be almost exhausted and the firewood shortage for the population will become more severe. One of the planting programmes are in progress using local species in Prey Veng and Takeo provinces on a small scale.

While 85% of the population live in rural area, the population of Phnom Penh and other urban centres is growing very rapidly. With growing population, more waste and garbage are often discared in rivers or dumped in open space in the suburbs. It is reported that the current sewerage system and the existing capacity of Phnom Penh to deliver the service is below its

pre-1970 capacity. During the wet season, rain water swells from sewer openings and spreads over residential areas, causing serious health hazards. In general, the large demand for limited housing in Phnom Penh has created city slums, overcrowding and squatting problems. Sufficient measures are required before the problems expand to surrounding sound rural areas.

As yet Cambodia has few industries, consequently the impact from industry on the environment is still minimal. Under transition to a market economy, however, the state enterprises have been released from the state control and the privatization programme has started. At the same time, many new factories have been established, while some are still under construction. There is already concern over the rapid increase in number of cottage industries without waste management facilities in urban and rural areas. It is required to stipulate environmental regulations, guidelines and standards to govern the sitting, technology or environmental practices of industries.

Since 1993, environmental education, though slow, has been permeated to the primary level of formal education sector, the training of government officials in MOE and sporadically the mass media and non formal education sectors. There is an urgent need for development and integration of national environmental education programmes at all formal education levels. The mass media, furthermore, including the traditional media and informal education need a lot of attention regarding the introduction of environmental education.

B.2.2. Environmental Conservation Aspects in Kandal Province

The Royal Government of Cambodia expressed a wish to join the Ramsar Convention in 1994. The first step of the process was to identify the sites of international importance for listing under the Convention. Field and aerial surveys were undertaken by MOE together with the Asian Wetland Bureau in April 1994 in the major wetland areas in Cambodia which have been previously identified as potential sites of the international importance (Figure B.2.1). As a result, three sites were recommended for the Ramsar list, as follows.

- Boeng Tonle Sap and its flood plain : A permanent lake on the northern side of Tonle Sap Lake, characterized by abundance of waterbirds and intact flooded forests, with numerous tributaries.

- Koah Kapik and associated islets : An estuarine ecosystem covering area of the islands, the creeks, open water, mud and sand flats between the islands, with large freshwater influence from two major rivers. There are three major vegetation types, namely the major mangrove community, the rear mangrove community and the beach stand vegetation.

- Middle Stretches of the Mekong river North of Stung Treng : This area is characterized by strong flow with numerous channels between rocky and sandy islands. The water is extremely turbulent with numerous whirlpools and areas of upwelling, but with relatively little white water. This is a riverine ecosystem with unique biodiversity and intact forests in the surrounding area.

Besides the above three sites, the site in the Bassac Marshes located between the Mekong and the Bassac river was recommended for further investigation and future listing. In March 1996, MOE prepared a wetland summary sheet on the Bassac Marshes, proposing it for National Park or Reserve and for follow-up field survey and waterbird inventory, on the account of the necessity to protect the high biodiversity potential. The site is still under consideration and so far no steps have been taken for the inventory survey (Figure B.2.2).

The site is surrounded by natural levees of both rivers. The natural levees slopes gently towards the inland, swamps, streams and lakes. Agricultural lands are distributed in the narrow band along the natural levees. Intensive farming is practiced in the area. Upland crops and vegetable are cultivated in the higher land, and rice in the lower land with silt bearing water supplied through colmatage canals.

Swamps are important for habitat of fish which migrates from the Mekong and Bassac rivers through the clomatage canals and streams. With its lower plain, lakes and swamps, the area

also plays the role of buffering the flood from both rivers. Many colmatage canals, 2 or 3 km in length, are distributed along both rivers, and they convey fertile sediment and water to farmlands and into backswamps during the annual flooding season of the Mekong river. Flood water is released toward both rivers as inundation subsides.

The Bassac Marshes area is located in four districts, Saang, Koh Thom, Leuk Dek and Kean Svay in Kandal Province. There are 16 communes concerned in which 5 are in Saang, 4 in Koh Thom, 3 in Leuk Dek and 4 in Kean Svay. These communes are mainly distributed on relatively higher land along the banks of both rivers (Table B.2.2).

Forests lands, covering 15% of land area, is consisted of thickets, shrubs, swampy vegetation and some trees in and/or around the communities, including home gardens (Table B.2.3). Kandal is said to be one of the most heavily deforested provinces in Cambodia. Also this area has poor shrubs and scarce forests. The main cause is believed to be the harvest of trees for firewood and poles for building and fishing by local villagers for local household use and/or selling.

Cultivated lands, covering 30% of land area in this area, are narrow and elongated strips along the Mekong and the Bassac river. Rice fields are located along the natural levees and banks of both rivers, and the fringe of swamps before flooding season. Rainfed lowland rice and dry season flood recession rice are grown mainly for home consumption. The dry season rice is accounted for approximately 40% of total rice crop of this area. The lack of water throughout the dry season and short dry spell in the wet season restricts rice production to one cropping per year, resulting in food shortage for 2 to 4 months in a year. The intensive farming system is practiced on the river banks and natural levees, which are primarily planted to vegetable and fruit trees, and in the lower area to maize, sesame and legumes. Availability of water during the dry season will enhance opportunities for agriculture activity along the Mekong and the Bassac river.

Most of the farmers are completely dependent on draught cattle for cultivation. For much of the year cattle rely on rice straw as feed which usually runs out before the next harvest. In general, grazing lands are extensive during the dry season but reduced during the wet season.

Fish and fish products have traditionally been the most important source of protein for the people. The Bassac Marshes area has 9 concession fishing lots, which accounts for 43% of Kandal fishing lots area. The fishery production in Kandal is about 20% of Cambodian inland annual capture. Fishing is mostly done by gill net, fish traps and fish corrals. In the southern end of Phum Prasat, located in the central area of the Bassac Marshes, one fish

corral spans the entire width of the main stream, though there are many smaller fish corrals in many of the side canals.

Phum Prasat, in the middle of this area, has the lowest population density, 60 persons per km^2. The villagers are mainly engaged in fishing, and grow rice on seasonal water standing fields, while maize and vegetables are grown on small size fields in shrubs before flooding season. The limited fields provide insufficient harvest for food. The villagers have no cattle except for a few fowls.

In the middle and southern areas, population density is lower than the western and northern areas of the Bassac Marshes area. There, fishing pressure is likely to be high, especially with the use of large fish corrals. In the rest of the wetlands fishing pressure is probably low due to the difficulty of access to most of the wetland and the narrow range of fishing gears.

Capture of birds is probably the major threat to their populations considering the numbers of lines with fishing hooks which were positioned within the wetland.
Disturbance to the wetland habitat itself is probably minimal, being confined to clearance of aquatic plants to aid transport through the wetland.

The wetland is important for support of the local communities through fishing, capture of waterbirds, collection of snails and use of the wetland for rice. The area filled with submerged plants is especially important as nursery, refuge and feeding grounds for fishes. The wetland performs a very useful function in retaining nutrients and sediments in aquatic plant beds as the water flows slowly through them towards the Bassac river.

Increased flooded area and duration have the potential to increase fish production. The area will meet some of the criteria for wetland conservation. However, it is prudent to compile an inventory in the Bassac Marshes area first to draw up a priority listing of a protected area.

B.2.3 Flora and Fauna

Forests in Cambodia are the most dominant vegetation covering 62% of total land, and support a lot of species of flora and fauna, including 212 species of mammals, 720 bird species, 240 reptile species and more than 2300 species of vascular plant. About 850 species of fish have been recorded in the Great lake and the Mekong river (MOE, National Environmental Action Plan Draft Report, 1996).

The forest vegetation in Cambodia is variously dominated by the families *Dipterocarpaceae, Leguminosae, Lythraceae, Fagaceae,* and in some places of limited extent by *Pinaceae* or *Podocarpaceae.* Bamboos also occur frequently. There are a number of rare and endangered tree species such as blackwood, Burmese ebony and Siamese rosewood in Cambodia (MOE, First State of the Environment Report, 1994).

The relatively large extent and diversity of forest cover maintain a diversity of wildlife. This fauna features a wide array of mammals including carnivores, primates, bears, elephants, rhinoceros, rodents, pangolins, bats, deer and native cattle. The vast wetlands feature a great numbers of waterbirds, most of which exist in the lower Mekong Basin.

The limited data available suggest that Cambodia is biologically rich and diverse and harbors several fauna species of global conservation significance listed in the International Union for the Conservation of Nature and Natural Resources (IUCN) Red Data Book (Table B.2.4).

In the Bassac Marshes area, some habitats reported in the field survey conducted by MOE in April 1994 are as follows:

- *Saccharum, Sesbania javanica, Ludwigia adsecendens, Echinocholoa, Colocasia, Scirpus grossus, Nelumbo* and *Barringtonia,* in the swamp savannah closest to Prasat Tuyo village.
- Water hyacinth *Eichhornia crassipes,* water lily *Nymphaea* sp. and *Ottelia* sp. in open water.
- *Azolla* together with duckweed, *Lemna* sp.,*Salvinia* sp.,*Ceratophyllum, Hydrilla verticillata* and *Najas,* with much growth of periphyton on the plants, in open water.
- The numbers of cormorants, herons, dabchicks and egrets with the diversity of waterbirds.
- Many young cyprinids with submerged macrophytes.

B.2.4 Institutional Framework for Environmental Conservation

There is still a lack of coherent management structures needed for sustainable use of ample intact resources in the country. The Government considers environmental conservation as critical, if the country is to prevent the types of degradation occurred as a result of excessive natural resource exploitation to drive economic development.

The Government has already undertaken significant actions, such as the zoning of 18% in the country into 23 protected areas, the establishment of the State Secretariat for Environment in 1993, now the Ministry of Environment (MOE), and the promulgation of the Law on Environmental Protection and Natural Resource Management in December 1996. The organization of MOE on technical tasks, renewed in April 1996, consists of six departments under Director General, namely Planning and Legal Affairs, Nature Conservation and Protection, Control Prevention and Reduction of Pollution, Socioeconomic Resources and Environmental Data

Management, Environmental Education and Communication, and Environmental Impact Assessment.

MOE has been given a broad mandate to protect the natural resources of the country and to prevent environmental degradation. MOE's strategy is based on the execution of responsibilities in conjunction with other Ministries concerning with specific aspects of natural resources and infrastructure management. MOE has been promoting for strengthening linkages between MOE and established Provincial Environment Offices and agencies in the line.

Though still in the formative stage, the functions of MOE are evolving to include the management of the national system of protected areas, pollution control, a central role in environmental impact assessment (EIA) that will be defined through a national EIA system, monitoring and analysis of human activity and natural system, environmental evaluation, and environmental education and communications.

Since establishment, MOE has had a number of issues in carrying out its basic functions : To promote drafting of laws, decrees and regulations for natural resource management, to develop and prepare guidelines and standards for evaluation on planning and implementation of projects, to strengthen government capability in technical skills and institutional capacity at the central and provincial levels, and to provide suitable budgets for implementation of environmental conservation activities.

Institutional framework and function on environmental management and resources conservation are in the process of reconstruction with financial and technical assistance from international organizations. Ongoing main projects are as follows.

- Cambodia Environmental Management Project (CEMP), formed with financial and technical assistance of United States Agency for International Development (USAID) to develop an overall strategic plan for MOE, to articulate the mandate of MOE, to identify, design and implement short term priority projects, and to enhance and improve planning skills for staff of MOE.

- National Environmental Action Plan (NEAP), a framework outlining major environmental issues and includes recommendations on strategies and programmes. The six thematic issues are Protected Area Management, Energy Development and the Environment, Management of the Tonle Sap Ecosystem, Offshore Fisheries, Urban and Industrial Pollution, and Commercial Logging. The World Bank is the main source of financial and technical assistance.

- Environmental Technical Advisory Project (ETAP), funded by United Nations Development Programme. The programme is designed to strengthen government capability in technical

skills and institutional capacity at the national and provincial levels with four objectives, namely environmental education and awareness, information management, capacity building of MOE and other related Ministries, and demonstration projects for improvement in wetland and parks management.

B.2.5 Policy and Guideline for Environmental Impact Assessment (EIA)

MOE has established an Environmental Impact Assessment Office, but its capacity requires strengthening. There remains a gap between Government plans & programmes and in investment projects undertaken by private sector.

External support agencies have been assisting MOE in the preparation of necessary procedures and legal framework for EIA. The Environmental Assessment Degree Draft has been under review by the Government. Asian Development Bank (ADB) has promised additional support to MOE for technical assistance in addressing legal instruments for EIA. International Development Research Centre, with ADB's support, is providing technical assistance in the preparation of EIA training, as well as institutional strengthening and capacity building, particularly for the Environmental Impact Assessment Office which is planned to be responsible for integrating environmental considerations into development planning.

EIA was originally conceived for evaluating infrastructure projects such as ports, industrial complexes, dams and reservoirs. Experience has shown that the various types or scale of plans, programmes and projects require different levels of environmental documentation. Accordingly, the requirements of the EIA process in most countries are based on the likelihood or the potential of an activity having a significant harmful environmental impact.

One approach is to phase EIA requirements wherein an initial environmental evaluation (IEE) is conducted at the early stages of every plan, programme or project. If there is sufficient justification to believe that the activity would cause insignificant negative impacts, or sufficient information to show adequate mitigation actions are needed in the IEE, there is no reason to prepare additional environmental documentation.

B.2.6 National Protected Areas System

The Degree of Creation and Designation of Protected Areas was declared on November 1, 1993. The total area of the 23 sites under the protected areas system occupies about 18% of Cambodia's land area. The new protected areas system includes areas previously designated in the 1960's and additional sites selected to ensure that diversity of habitats in Cambodia are represented (Figure B.2.3).

The four categories of protected areas reflect the different characteristics and management objectives for these areas, and they correspond to international classifications as follows.

National Parks : Natural and scenic areas of significance for their scientific, educational and recreational values.

Wildlife Sanctuaries : Natural areas where nationally significant species of flora and fauna, natural communities, or physical features require specific intervention for their perpetuation.

Protected Landscapes : Nationally significant natural and semi-natural landscapes which must be maintained to provide opportunities for recreation and tourism.

Multiple-use Management Areas : The areas which provide for the sustainability of water resources, timber, wildlife, fish, pasture and recreation with conservation of nature primarily oriented to support these economic activities.

B.3 Aspects of Environmental Impact

B.3.1 Policy and Concept for Environmental Conservation

Cambodia is endowed with rich natural resources for human, agricultural and industrial use. They have been seriously degraded over the past two decades. A major portion of the natural environment is still intact. However, it is expected that there will be more pressure on natural resource bases due to growing economic and social interests. If natural resources are effectively managed and controlled, to promote economic development with careful planning, they can bring beneficial results with minimum negative impacts on the environment.

Land and water resources and the associated plant and animal are the focus of environmental concerns. Land use planning in wetlands should be considered together with other land use, since the coordination of interests of different sectors, namely agriculture, forestry and fishery is essencial. Appropriate legislation focusing on specific issues is needed to help resolve resource and land use conflicts. The basic long term approach, in virtually all sectors related to land and water resources, is consisted of institutional strengthening, interagency cooperation and strategic planning within the agencies for concerted efforts in better resource management.

Forests are indispensable for protecting fragile environment. According to Cambodia Land Cover Atlas in 1994, the forest cover is interpretated by the 1992/93 landsat imagery measures at 112,842 km^2 or 62% . However, forest cover is unevenly distributed throughout the country. The study area has lost most of its forests and is experiencing serious shortage of fuelwood. The main pressures on the forests are said to be rooted from increasing logging activities, uncontrolled forest fires, increasing demand for agricultural land, fuelwood for charcoal production and other domestic uses. The Royal Government has imposed a ban on the cutting down of trees since January 1995 and on log export since April 1995.

Forests are essential for the preservation of soil and water and for the maintenance of bio-diversity, yet agriculture and commercial forestry contend for the same land and biological resource base. Encroachment on forest and wetland ecosystem will have an adverse effect on the diversity of plant and animal species. The flooded forests are the traditional source of nutrients necessary to sustain the large and varied aquatic biota with ecosystems standing on the Mekong river system. Since this heritage has long provided people with a wealth of resources, a primary environmental challenge is to preserve biological diversity for future.

The rehabilitation and improvement of irrigation systems are likely to increase the availability of water for cropping in the dry season and dry spell during the wet season. It will result in introduction of intensive farming system on existing farmlands with the

expectation of high production. As a result of the efficient land use, it can help to avert illegal exploitation of the flooded forests. However, farmers will be tempted to increase the amount of fertilizers and agrochemicals without proper application knowledge, unless sufficient extension service and guidelines are provided to them.

Community organization and the establishment of water users groups are essential to guarantee the operation of efficient use of water, operation and maintenance of the canals and appurtenant facilities, dredging of sediment on canal bottoms year after year, and for the sustainable colmatage farming system after rehabilitation programme. Using water equitably and efficiently in an environmentally responsible manner will require the effective cooperation efforts of all users.

The inland fishery is seriously depleted, with the high rists of losing some species. The continued reduction in commercial annual catch has served as an important means to understand the sevserity of problem. The vast inundated area also provides an ideal environment forpropagation and dissemination of a wide varieties of aquatic species. Intensive fishing has led to reduction in catch of some large-sized fish species. Development and management to increase large-sized fish should be carried out in a manner paying considerable attention to the environment if production is to be sustained. Sustainable fish harvesting allows fish to reproduce at a level that maintains a stable population. Stocks should be protected from over fishing pressure during the breeding season in the fishing grounds. Moreover, educational campaigns and workshop on sustainable fishing should be unremittingly conducted for all parties concerned in fishery, to avoid conflict between farmers and fishermen in some areas.

With growing of economic activities, urban and industrial pollution sources will contribute to water quality degradation, and will affect the ecosystem of wetlands, water resources and the productivity of the inland fishery. Progressive actions should be practiced to protect them. Waste water, sanitation and solid waste management are environmental issues affecting the urban environment. The policy for sound urban environment conservation should involve strengthening local institutions to better management of infrastructure, public service functions and the financing for infrastructure setting.

Water resource protection plans should be developed and be provided with sufficient controls to limit impacts on water bodies. It will allow for future urban and industrial growth without imposing threats to beneficial uses of water resources. There is a need for further development of a river basin monitoring programme, a comprehensive database system, continuous evaluation system and information system to all users about the natural resources and the environment in the whole basin and its sub-basins.

B.3.2 Aspects of Environmental Impact

The Mekong river exhibits a pronounced annual variation in flow. The annual flooding cycle in the study area is inherent under the hydrological influence of the Mekong river. In addition to overflowing the banks or levees, the flood of the Mekong river pours its abundant water to a lot of reservoirs and backswamps through tributaries and colmatage canals distributed along the Mekong and the Bassac river. It is not possible to control the vast annual phenomenon of the Mekong river. The flooded area expands and contracts with the fluctuating water level.

Most of irrigation systems in the study area have lost their previous function due to poor maintenance and annual flood damage, in particular water control gates. Colmatage canals have a significant role for conservation of natural environment and activities of agriculture and fishery through controlling inflow and outflow of flood water rich in sediment. Most of the canals require dredging and repairing or installation of gates.

The study area has a high level of seasonal rainfall and seasonal surface water. Despite the abundance of water sources, some areas are devoid of water in the dry season. The rainfed rice is grown on relatively higher lands, which are not subjected to severe annual inundation but are far from water resources such as streams, springs, lakes, reservoirs, or ponds. Farmers in such areas are dependent on unreliable rainfall pattern for cropping. As a result, harvest is poor or the crop fails completely in some years, and fallow lands are covered with dominant weeds like *Mimosa pigra* during the dry season.

Water availability is seen as the main factor limiting the extent of irrigation in the study area. It is recommended that limited water resources availability is matched with more suitable land use and soil resources, in order to maximize agricultural production. The rehabilitation project aims to restore the function of the structures deteriorated during past decades. Since this project is planed without new construction and elongation of colmatage canals, and its implementation scale is not so large that social and natural environment in the surrounding area will scarcely change Hydrological regime of the irrigation systems will have slightly positive effect on water storage and flow. Considering the extent of flooding by the Mekong river, irrigation rehabilitation has negligible impacts in hydrological situation.

The Mekong river basin is rich in wetland environment. Wetlands comprising of floodplains and flooded forests serve a wide variety of ecological functions which support important economic activities in agriculture, fishery, tourism, energy and cottage industry. At this stage, there are little reasons on aspects of environmental situation after the

rehabilitation work.

Agricultural activities require a constant supply of sufficient water, especially for rice production which has a significant economic role. With increased water availability after rehabilitation and improvement of irrigation systems in the study area, cropping period will be stretched into the dry season, and sufficient irrigation will be provided to water scarce areas in the wet season.

Increased access to water will help to increase yields and to diversify crops. It may also encourage farmers to introduce more profitable and stable cropping system and intensive agriculture, and may be expectd to prevent indiscriminate exploitation in flooded forests. However, intensive farming system might lead to indiscreet and risky application of agrochemicals and fertilizers with insufficient experience, lack of proper knowledge and poor information, particularly pesticide use. Overuse of fertilizers and pesticides will cause adverse effects in the backswamp water. In any case, more efficient nitrogen use, namely reduction of the over application should be promoted through the extension service, especially in conjunction with more efficient crop production method.

The reservoirs and the colmatage canals in the study area play a significant role for the fishery, as well as lakes, streams and swamps in the rural area. During flooding season, they provide the fishing grounds for artisanal small scale fishery and family fishery in the vicinity of water bodies.

The goal of the rehabilitation and improvement of irrigation systems in the study area will be the restoration, security or increase in storage capacity of the reservoirs, not only for irrigation during the dry season and for extension of cropping period in the wet season, but also for fishery ground conservation. In the study area, it is said that there are some threats of degradation of fishing ground by overfishing, in particular large-sized fish. Water bodies rehabilitated will contribute to preserve the fishery grounds.

In the study area, flooded forests are scarcely found, particularly in Prey Veng, Takeo and Kandal, while shrubs are widely found in and around swampy area. It is said that firewood extraction and agricultural pressures are the main threat facing the scarce flooded forests and shrubs. Since most of the lands, however, have already been developed for farmland with irrigation systems, there is no reason to believe that the rehabilitation of the existing irrigation systems will cause negative impacts on the existing forests in the study area. The rehabilitation works, however, should be conducted taking account of the remaining forest to be reserved. It is recommended that campaign for preservation of the existing forest and additional tree planting are implemented in all areas, disregards of whether the

rehabilitation work are proposed or not.

In a long term, land reclamation through sedimentation in the low lying areas will be extended toward swamp areas and inundated forests. The land might be changed into farmlands. When this happens, optimum land use concept including agriculture, fishery, natural ecosystem has to be defined, in which zoning of environmental conservation should be delineated politically, socio-economically and technically.

Most of the irrigation systems have not been operated in a way which encourages efficient use of water, due to a lack of awareness of the important of irrigation structures and proper water management. It is necessary to promote measures enhancing farmers' awareness of equitable and efficient distribution of water, otherwise rehabilitated systems will bring no benefits and may detariorate again.

Accordingly, the establishment of water users groups will be required for proper operation and maintenance of irrigation systems, to sustain productivity, to preserve sound ecosystem and to avoid conflicts between farmers and fishermen.

In the case of water extraction from a tributary, the plan is required to take account of the hydrological influence on the downstream area and fishing grounds, especially in weir construction plans.

In general, the study area is in the developed regions of the country and no specific issues of ecological concern are found in the proposed projects which aim to rehabilitate the colmatage canals and the irrigation systems. During the implementation of the rehabilitation work, however the work will cause temporarily some disturbance in the project area. It should be managed with reasonable measures to minimize the environmental impacts during and after the rehabilitation work.

B.4 Environment in the Boeng Phtea Area

B.4.1 Environmental Aspect

B.4.1.1 Social Environment

The goal of the agricultural development plan harmonized with the development of fisheries, is to promote fishery ground conservation, as well as irrigation during the dry season and extension of cropping period in the wet season with the restoration, security and increase in storage capacity of reservoirs. For the feasibility study, the field evaluation was carried out on environmental aspects in the study area initially, based on the above criteria.

While the Mekong river supplies its abundant water with fertile sediment for agricultural production and fishing ground annually, its performance has controlled cropping area and season which have potential on agricultural production increase. In addition, it has limited rural development with giving damage on poor infrastructure in the lower Mekong river basin. The five communes are composed of ordinary rural village being similar to other region under the Mekong river regime, including 20 villages in the area. There is no back ground of rapid change in population growth, such as sponsored and/or spontaneous resettlement, industrial expansion, urbanisation and, so on.

The life style in communes is still based on paddy culture under the annual Mekong river cycle. Most villagers rely on paddy production with one harvest per year. Farmers help each other in paddy transplanting and harvesting, with providing meals and no wages due to lack of the available labour in a family, according to their paddy field acreage in general. Large paddy field holders are able to hire labourers to crop paddy. There is some economic gap among villagers according to cultivable acreage and water availability for cropping, and income opportunities.

There are several dike management systems in the area, which have worked with poor management with scarce resources of money, rice and labour which is provided by farmers belonging to the reservoirs. In general, authorities in communes have capability to arbitrate between interested and affected parties. There is no information of serious conflicts between farmers and fishermen, and among villagers and communes.

Through the media, especially TV, most villagers have access to a lot of information which will help them to modernise gradually with the central economic growth, for example they can become aware of technological renovations especially in term of agricultural equipment and, so on year after year. There is a lack of sufficient information and services regarding the

development of agricultural and fishing skill which will in turn enable villagers to increase their income.

Agricultural production has contributed the communal economic sector in the area, with rice and mat grass being cropped except the flood season. Some lotus ponds are found here and there, some in reservoirs, some in standing water fields, in the dry season. Agricultural productivity has stood on relatively lower level. Lands for agricultural exploitation are limited due to most of the land having been developed for paddy fields so far. On the other hand, a lot of paddy plots are abandoned due to lack of irrigation water except some years. This results in plots being covered with *Mimosa pigra* which disturbs any crops growing.

Most villagers have expected to improve present infrastructure situation and to bring many and large benefits in the area. Farmers have interested in the intensive farming system with irrigation water and agrochemical application to increase yield from limited their farmland. Agrochemical application has been practiced on some paddy fields including some pesticides of WHO class I a, with lack of proper knowledge to apply, because marketing information is limited. Under the situation of cultivable land shortage and low yield, most farmers will aim to practice intensive and/or diversified farming systems.

The experience of 300 farmers is shown in Table B.4.1, on using pesticides and insecticides, with random sampling in two villages along the Mekong river and one village at the eastern area. About 93 % of the farmers have used pesticides. The information on pesticides have been obtained from friends (40 %), markets (30 %) and extension workers (30 %). About 45 % ofthe farmers have been using pesticides since early 1980s. About 54 % of the farmers re-apply and/or increase the dosage when the effect of previous application is scarce. They have used one or more than one of the seven kinds of pesticides. Folidol and Azodrin are popular among the farmers and used by a large number of farmers, shown in Table B.4.2. Those are classifiedin WHO Ia and Ib as an organic phosphorus compound. Table B.4.3 shows the pesticide and insecticide used by the farmers and sold in the markets in the area, and WHO classification. Most of the farmers hope for proper know-how on pesticides use. Uncontrolled use of those pesticides is likely to cause many negative environmental effects in future.

Buffaloes contribute significantly in paddy cropping in this area, through providing draught power and manure to fertilise the soil. They feed on grass in paddy fields in the dry season, and have to rely on paddy straw in the flood season, even on banana stems in spell of shortage.

Fishery is a significant sector next to rice for food and income in the area. No.17 fishing lot shares the Phtea lake and the Totul stream flowing from the Phtea lake. Since the lot is controlled by concessionaires, farmers and family size fisheries have depend on only small

size fish capture, including still young fish, for food and some income without the capture season of commercial fisheries.

Firewood is still the major source of fuel for cooking in the area. Most families depend on the flooded forests and shrubs around the Phtea lake and streams for their use and sale. On the other hand, they resort to dung sticks, leaf stalks, rice husk and even straw when firewood is locally scarce. Some kinds of trees growing over in paddy fields and on dikes become firewood sources, even *Mimosa pigra*. As firewood, Reang in Khmer on *Barringtonia micrantha* and Troas on *Combretum trifoliatum* are used in general, as Table B.4.4. Those trees grow rapidly in anywhere, even in the present reservoirs in the area. For sustainable firewood source, the forests should be maintained by villagers under a regulation.

Few ferry routes are available across the Mekong river from the national road route No. 6A, but not at night or under strong wind. Two main rural roads link five communes in the area. Rural roads are still under poor condition, and submerged all parts during the flood season, except two the main roads.

Drinking water sources are mainly the Mekohg river and rain water, and some villagers depend on streams and lakes. There are simple water systems in villages, which are composed of tube wells, pipelines and hand pumps. Hygiene and the medical situation, and drinking water safety are still at a lower level. There is little information on crucial infection and/or endemic disease so far except popular parasites.

There are no places for historical and cultural importance to preserve, except temples in the area. Several temples stand on the higher places in communes, which are not submerged and become one of harboring places for villagers in the critical flooding season.

B.4.1.2 Natural Environment

This study area is belonging to a part of a vast floodplain along the left of the Mekong river in Khsach Kandal district in the Kandal province. The area located close upon the confluence of the Mekong river and the Tonle Sap river, has been under the great influence of the Mekong river regime, namely the annual flood. The Mekong river has provided a broad range of benefits with abundant water, rich in sediment and organism, on agricultural and fishing activities in the area like other flooded area. The area also performs a role of a buffer zone in the flood season annually.

The Mekong river pours its abundant water over the area through the Khcho lake located in the northern and colmatage canals along the Mekong river. At the same time, the Toch river

sends lot of water to the Veal Samnap lake placed in the south. The lake engorged water disturbs flowing water from the Phtea lake. As a result, water expands its surface on about 90 % of the area in September, and deposits sediment on the ground. Its sediment provides fertility for paddy fields, and raise the bed of water bodies including reservoirs slightly year after year. The Mekong river phenomenon will continue unless a drastic change occurs on the Mekong regime.

At present, there are no disturbances of critical pollution on water and soil originated by factories and urban waste. There is no evidence of serious eutrophication in water bodies in the area at present. However, the overuse of agrochemical should be monitored by the local authorities, and the proper waste management should be conducted at the same time.

The ecological systems and human life style in the study area have been controlled by the Mekong river regime. Its ground will be reserved with rich sediment and organisms carried by the Mekong water, even under a developed situation in the lower river basin. There is no data on specific soil like saline soil.

While the area is already disturbed by paddy field exploitation so far, there are still several flood forests and shrubs around the Phtea lake and streams, and also in reservoirs. Those forests have performed significant roles in harboring and breeding fish, propagating small life. While lot of vegetation have reserved ecological ground, some of them provide economic benefits as materials for building and fishing gear making, traditional medicines and fuel.

Flooded forest is still the major source for firewood in this area. The vegetation growing in flooded forests and shrubs around water bodies and in reservoirs has contributed to reserve their ecological system and breeding grounds for fish and small life. Several trees confirmed in the field survey, are known its rapidly and easily growing in anywhere and throughout the year. Some shrubs are shared by specific kind of plants, like *Mimosa pigra*.

Most of the forests have been formed by lots of common plants, such as local name Reang on *Barringtonia micrantha*, Phnek preap on *Breynia rhamnoides*, Troas on *Combretum trifoliatum* and Nhor on *Morinda citrifolia*. Those plants grow rapidly and spread easily by seed and seedling in anywhere, even in reservoirs. Trees stand few and far between ridges and/or corners of paddy plots. Those branches are used for firewood. *Mimosa pigra*, one of the dominant plants, spreads easily and rapidly, and forms thick bush by seeds especially around water bodies and in fallow grounds. The plants confirmed in the field are shown in Table B.4.5, which are listed from the inventory of the Forest Department as common vegetation samples in the floodplain. Among 83 species, existing plants in the area are counted as 62

species, in which 54 plants are found easily in anywhere growing densely, and 8 species are distributed sparsely here and there. Among of 62 plants, 18 have not been confirmed in scientific name.

Water bodies and flooded forests compose important circumstances for ecological environment on fauna and flora. An inventory has been prepared by the Forestry Department in the countrywide so far. Though flooded forests become scarce in the area, some sensitive life might be found, such as small animals, waterfowls and reptiles. There are probably many kinds of fauna and flora in and around the Phtea lake and streams. An inventory on important aspects of them has been prepared by Forestry Department in the countrywide so far. However, there is deficient data in detail on their existence in the area. In this time, several waterfowls are confirmed with the list picked up the inventory of the Forest Department. The results are shown in Table B.4.6

On fish, 35 species listed in Table B.4.7, from the fish inventory of the Fishery Department, are identified in the area. Those fish, such as snakehead, catfish, gobi, barb and so on, are sold in local markets and in Phnom Penh in popular, with some high price some cheap. Among 35 fish, 10 large size fish are exported. Some kind of fish are pointed out its lower population with overcapturing recently. There are no data about extinct and/or endangered fish species in the area. Since fish is very important resource for not only diet but also income generation for villagers, fish breeding ground should be monitored periodically and preserved under local authorities.

Several kind of species on tortoises are found in the area, such as Andeuk pleung, Andeuk sakol, Andeuk prech and Andeuk betmeuk in Khmer. Many kind of snakes are reported in the countrywide. Pos vek in Khmer on *Naja tripudians* which is one of poisonous snake around one metre length, is found all season. It removes on trees in the flood season. Pos thlann is one of snakes in popular to catch rats in paddy field. These situation is no change after the project.

B.4.2 Environmental Impact by The Project

B.4.2.1 Social Environmental Impact

In general, there are some impacts on the agricultural activity, effectively and directly. The negative impacts on the social environment directly will not occur after the project, such as resettlement, rapid population increase, and conflict between farmers and fisheries. Next to agriculture, it is the most effective impact on the economic activity in the area that the new road network improves the traffic condition on products conveyance and villagers

more convenient than at present throughout the year.

The framework of development plan for the area is proposed to construct and rehabilitate multipurpose reservoirs, farm roads and dikes, irrigation canals, and the weir at the Boeng Pthea in the first stage, to rehabilitate and expand colmatage canals and intake gates in the second stage, and to construct the linkage road between the western area and the eastern area and the flood control gates in the Phtras Konlong road in the third stage.

The renewed reservoirs provides the stable condition and increases the cropping rate on the recession paddy cropping which have been limited due to lack of water in the dry season. At the same time, availability of irrigation water will be able to recover the agricultural productivity from abandoned paddy fields, and to open the way toward cropping diversification. Since the flooded forests preserve for the firewood resource in the reservoirs, the proper maintenance will be able to contribute on the conservation of the vegetation around the Phtea lake. In addition to above, fish breeding grounds will be provided when new user's groups operate and maintain properly the water control gates and dikes of the reservoirs.

After the construction and rehabilitation of infrastructure on agriculture, the positive impacts are expected on the social environment, such as to encourage agricultural activities to increase production, to promote the organisation of the user's groups of the operation and maintenance on the facilities, to train farmers for higher yield effectively, and to promote agricultural extension service systems, and consequently to boost the rural economic activity and to upgrade of living standard in future.

Due to the colmatage farming system still practiced after the project, agrochemical apply are not promoted more than at present. For gaining high output, there are many difficulties, such as lack of excellent extension workers, deficient information for agrochemical use like guidebooks, no labels on packs and bottles in Khmer, and training systems for farmers.

After the improvement of the rural infrastructure, the responsibility to manage on the renewed facilities use should be imposed reasonably on users and villagers to maintain and to develop the productivity of farmlands and fishing grounds. The villagers should be trained their skill to operate and maintain the renewed facilities at the operation and maintenance supporting office proposed in the project.

During the construction and rehabilitation works, some income opportunities will be created temporarily such as providing labourers, materials and equipment, transporting workers and people concerned, and selling foods and beverages in and around the sites.

B.4.2.2 Natural Environmental Impact

Most of arable area are already exploited for paddy cropping so far. There are no spaces for expansion of agricultural lands more than at present in the area. The natural ecosystem is preserved scarcely in the flooded forests around the Phtea lake. There is no disturbance on the natural environment by the project, because of no exploitation in the flooded forests and no restriction on the Mekong river regime.

After the first stage of the project, the flooding water expansion will be restricted on the relatively higher land in the part of the east area. In general, there is no disturbance on the flooding water flow, because some spaces are remained across the new farm roads and the broad space of the outlet of the Phtea lake. The completed water gates of colmatage canals in the second stage, will control the flooding water in and out in the area impounded by the farm roads along the Mekong river. It will lead to being extension the cropping area and its season. In this time, the flooding water will be little restricted in flow.

As the third stage, the construction of the control gates and the linkage road should be considered together with a development plan which will be projected comprehensively to control the flooding water flow in the floodplain linked with this area, because the water control by the gates will disturb the some amount of the discharge of the flooding water from the northern area.

The Phtea lake and its streams are the major water body in the area for reproduction ground on fish throughout the year. A lot of fish migrate into the water bodies in the area for the flood season. The weir planning across the outlet of the Phtea lake, expand the water surface and preserves the flood water in the dry season, more than at present. The flooded forests are protected with expanded water surface from taking firewood, and provide habitat for fish. The sustainable advantage on the native fish gets no change, for fish breeding with aquatic vegetation and rich organic matter carried by flood water.

B.4.2.3 Environment Conservation Plan

It is essential that the constructed and rehabilitated reservoirs, canals and roads should be maintained properly by villagers in the area to keep the sustainable function for the future. At the same time, the district authority and the user's organisations should practice the progressive measures over the forests in the reservoirs as sustainable firewood resources to equalise its benefits among villagers and to reproduce, such as patrolling to prevent illegal cutting trees, zoning to protect natural resources, and planting trees as firewood resources. Due to doing above measures, the consensus and the awareness among all villagers should be

required on the importance of maintenance for the future use.

Since it is said in general that there are some anxieties by agrochemical pollution from an intensive farming system, MAFF should strengthen the extension services to guide the proper application and to prevent misusing. The Integrated Pest Management Programme (IPMP) conducted by CIAP so far, also should be promoted actively because of effective measures to restrict agrochemical use. At the same time, some pesticides including organo-phosphates which are listed in the WHO list as extremely and highly hazardous chemicals for life, should be regulated strictly to use and sell.

It is important to accumulate data observed in field for checking environmental change in the middle and long term. The change of the water quality affects the natural environment and fishing resources which should be conserved. The Department of Irrigation Meteorology and Hydrology of MAFF should analyse water samples collected at the upper and down points of the Phtea lake in the same day of the beginning and the end of the dry season yearly, with cooperation of the authority, based on the checking standard of the Department. Its results should be watched periodically the change.

Fish is the important protein resource for the domestic diet. The Department of Fishery of MAFF should survey the distribution of fish captured in the area in the peak with cooperation of fisheries, and the population of fish sold at markets periodically in the both season of dry and wet, for preservation of resources and sustainable production.

With improving the social infrastructure and promoting agricultural activities, consequently living standard rising gradually might request to measures against increasing firewood consumption and wastes and polluted water in living. MOE has been pushing forward building up the central and rural organisations and improving the capabilities of staff. Moreover, MOE should boost up to increase the awareness in villagers on hygiene improvement and natural resources reservation, to popularise fuel efficient stoves, and to train the proper waste management.

The inventory of plants, bird and small living in the area is valuable as data base of genuine conservation for the future. The Department of Forest of MAFF should collect and review the regional data with cooperation villagers as possible in some years periodically to preserve the ecological environment, with promotion the awareness on importance of natural resources preservation among villagers.

Table B.2.1 Land Cover Altas by Landsat, Area in km^2

Province	Kratie		Kompong Cham		Kandal		Prey Veng		Takeo	
Land	1985	1992	1985	1992	1985	1992	1985	1992	1985	1992
1. U	0	0	0	4	8	1	0	0	0	0
2. Ar	447	730	1781	2197	321	542	3068	3594	1740	2168
3. Af	0	0	0	0	0	0	0	0	0	0
2~3	447	730	1781	2197	321	542	3068	3594	1740	2168
4. Au	55	89	760	732	248	267	17	37	219	288
5. As	6	10	72	73	0	0	4	50	0	0
6. Ao	0	0	16	184	0	0	0	0	0	0
7. Ap	53	22	729	717	0	0	0	1	0	0
8. Av	174	245	948	1315	957	1467	458	708	191	188
4~8	288	366	2525	3021	1205	1734	479	796	410	476
9. Fe	3164	3122	1431	1319	0	0	14	21	0	0
10. Fc	0	0	0	0	0	0	0	0	0	0
11. Fd	5867	5190	389	474	0	0	0	0	114	4
12. Fx	1038	1195	32	316	0	0	0	0	0	0
13. Fs	123	4	449	181	3	6	41	6	78	8
9~13	10192	9511	2301	2290	3	6	55	27	192	12
14. Ff	99	0	871	453	789	706	302	79	284	185
15.Fsf	0	0	4	0	129	22	48	14	63	45
16. Fm	0	0	0	0	0	0	0	0	0	0
14~16	99	0	875	453	918	728	350	93	347	230
17. St	429	526	5	50	2	14	2	34	2	7
18. Sn	199	465	929	973	350	160	315	167	311	250
19. Sa	14	15	362	123	65	27	71	0	22	6
20. Ss	0	0	63	0	9	0	12	0	4	0
17~20	642	1006	1359	1146	426	201	400	201	339	263
21. G	0	0	0	0	0	0	0	0	0	24
22. Gs	0	0	0	0	0	0	0	10	0	0
23. Gf	0	78	87	1	102	68	32	32	11	172
24. Ga	38	27	91	5	0	10	8	8	65	37
25. Gm	0	0	0	0	196	0	21	0	25	0
21~25	38	105	178	6	298	78	61	50	101	233
26. W	296	310	315	202	441	282	434	74	301	46
27. Bl	60	33	24	39	43	91	0	12	0	2
Total	12062	12061	9358	9358	3663	3663	4847	4847	3430	3430

Source : FAO, UNDP, Mekong Secretaiat 'Canbodia Land Cover Altas, 1994'
U=Urban/cities, Ar=Paddy fields, Af=Receding and floating rice fields,
Au=Upland crops on slope terrain, As=Swidden Agriculture, Ao=Orchards,
Ap=Plantation of rubber, Av=Field crops on the river bank flooded areas,
Fe=Evergreen forest, Fc=Coniferous forest, Fd=Deciduous forest, Fx=Mixed forest,
Fs=Secondary forest, Ff=Flooded forest, Fsf=Flooded secondary forest,
Fm=Mangrove foerst, St=Woodlands of scattered trees, Sn=Natural shrublands,
Sa=Abandoned shrublands, Ss=Swamps, G=Grasslands, Gs=Grass svannah,
Gf=Flooded grasslands, Ga=Abandoned grasslands, Sm=Marshes, W=Water surface,
Bl=Barren lands.

Table B.2.2 Population and Land Use in the Bassac Marshes Area in Kandal Province

	Province	Districts[1]	Proposed site[2]
1. Population	944,465	438,874	168,169
2. Commune	147	46	16
3. Village	1,080	279	110
4. Family	182,439	86,632	30,988
5. Natural land (ha)	355,542	177,229	85,247
6. Agricultural land (ha)	144,355	61,447	26,069
7. Forest & shrub (ha)[3]	30,702	13,736	12,477
8. Other land (ha)[3]	180,485	102,046	46,701

Sources : Statistical Data in May 1996, Administrative Office of Kandal Province
Note : 1) Districts are Saang, Koh Thom, Leuk Dek and Kean Svay.
2) 'Proposed site' means the area of communes concerned where was prepared the wetland summary sheet to recommend for protected area as National Park or Reserve
3) Data of 'Forest & shrub' and 'Other land'are from 'the land situation in 1989 by the Planing Office of Kandal Province'.

Table B.2.3 Population Density and Planted rice area in Bassac Mashes in May 1996

1) Kean Svay District

Commune Name	Village	Family	Population	Density	Land(ha)	Wet Rice	Dry Rice
I. Proposed area				/km²	ha	ha	ha
6. Dei Eth	3	2,277	13,090	524	2,498	214	569
7. Banteay Dek	3	1,768	9,983	173	5,763	50	1,026
8. Samrong Thom	6	2,977	15,135	178	8,478	221	1,092
9. Koki Thom	4	1,870	9,527	220	4,330	-	480
10. Kompong Svay	3	1,553	7,523	329	2,288	204	360
11. Chheu Teal	4	1,368	6,975	323	2,160	151	280
Subtotal	23	11,813	62,233	244	25,517	840	3,807
% to Total	50	41.8	52.9		66.8	58.7	77.9
II. Out of area							
1. Veal Sbou	4	1,117	5,621	586	960	-	10
2. Prek Eng	6	1,541	7,816	379	2,060	-	81
3. Kbal Koh	3	2,378	11,038	557	1,981	48	279
4. Phum Thom	3	1,597	8,607	460	1,871	41	239
5. Koki	4	7,571	10,281	460	2,235	101	174
12. Prek Thei	3	2,243	12,055	356	3,387	400	294
Subtotal	23	16,447	55,388	436	12,694	590	1,077
III. Total	46	28,260	117,621	308	38,211	1,430	4,884

2) Leuk Dek District

Commune Name	Village	Family	Population	Density	Land(ha)	Wet Rice	Dry Rice
I. Proposed area				/km²	ha	ha	ha
1. Km Phnom	4	2,139	10,588	135	7,851	50	500
2. Prek Tonlep	4	1,685	9,260	125	7,429	214	527
3. Prek Dach	4	1,102	6,137	96	6,372	150	420
Subtotal	12	4,926	25,985	356	21,652	414	1,447
% to Total	50	62.2	60.6		58.2	53.4	36.2
II. Out of area							
4. Peam Reang	3	1,017	6,038	108	5,572	-	910
5. Khpob Ateau	3	662	3,272	92	3,351	200	500
6. Sandar	3	633	4,071	136	3,001	85	452
7. Kaom Samnor	3	687	3,495	102	3,438	77	682
Subtotal	12	2,999	16,876	108	15,564	362	2,549
III. Total	24	7,925	42,861	115	37,216	776	3,996

3) Koh Thom District

Commune Name	Village	Family	Population	Density	Land(ha)	Wet Rice	Dry Rice
I. Proposed area				/km²	ha	ha	ha
6. Por Ban	9	1,705	9,277	199	6,451	142	585
7. Kampong Kong	11	1,989	11,434	423	2,700	200	800
8. Leuk Dek	11	2,083	11,365	152	7,501	-	5,898
9. Chroy Takeo	9	1,424	8,615	213	4,050	390	869
11. Prek Chrey	4	1,540	9,425	167	5,650	22	430
Subtotal	44	8,741	50,116	190	26,352	756	8,582
% to Total	47.3	40.5	40.6		49.4	37.4	58.3
II. Out of area							
1. Koh Thum(ko)	6	1,133	6,344	705	900	295	600
2. Koh Thum(kho)	5	1,268	7,144	397	1,801	268	814
3. Prek Thnei	12	3,012	16,857	519	3,250	185	220
4. Prek Sdei	9	3,060	17,874	325	5,500	70	1,950
5. Sampauv Poun	9	2,863	16,168	170	9,501	242	1,510
10. Chheu Khao	8	1,584	8,901	185	4,800	200	1,045
Subtotal	49	12,830	73,285	272	26,952	1,260	6 139
III. Total	93	21,571	123,401	245	53,304	2,014	14,721

4) Saang District

	Village	Family	Population	Density	Land(ha)	Wet Rice	Dry Rice
I. Proposed area				/km²	ha	ha	ha
12. Khpob	10	2,104	10,730	323	3,321	203	1,200
13. Ta Lun	9	2,041	10,205	350	2,913	235	607
14. Treuy Sla	9	2,863	15,010	294	5,100	407	970
15. Svay Proteal	9	2,092	10,674	299	3,570	442	406
16. Prasat	5	867	5,169	59	8,720	-	822
Subtotal	42	9,967	51,788	219	23,624	1,287	4,005
% to Total	35.3	34.6	33.4		45.9	15.7	47.1
II. Out of area							
1. Svay Rolum	5	1,374	6,876	635	1,083	535	100
2. Koh Anglongchi	4	905	4,197	507	828	-	-
3. Setbo	4	1,143	5,801	329	1,761	300	150
4. Roka Kpoas	5	1,389	8,034	231	3,482	750	600
5. Prek Koy	7	2,009	10,235	651	1,571	317	188
6. Saang Phnom	9	1,868	9,777	257	3,800	901	618
7. Krang Yeu	15	2,465	12,691	264	4,800	1,545	716
8. Teuk Vill	8	1,414	8,528	330	2,603	252	550
9. Koh Khel	6	1,546	11,397	552	2,064	200	827
10. Prek Ambel	9	3,872	20,260	410	4,936	1,706	550
11. Koh Khsach Ton	5	927	5,347	566	944	413	200
Subtotal	77	18,859	103,203	371	27,872	6,919	4,499
III. Total	119	28,826	154,991	301	51,496	8,206	8,504

Souce : Data of Administrative Office of Kandal Province

Table B.2.4 Species of International Conservation Significance Known to Occur in Canbodia

	Scientific Name	IUCN classification	
Manmals			
Asian elephant	*Elephus maximus*	E	
Asian golden cat	*Catopuma temmincki*	I	
Asian wild dog	*Cuon alpinus*	V	
Banteng	*Bos javanicus*	V	
Black finless porpoise	*Neophacaena phocanoides*	K	
Black gibbon	*Hylobates concolor*	E	
Brown antlered(Eld's)deer	*Cervus eldii*	V	
Chinese white dolphin	*Sotalia chinensis*	K	
Clouded leopard	*Neofelis nebulosa*	V	
Douc langur	*Pygathrix nemaeus*	E	
Dugong	*Dugong dugong*	V	
Fishing cat	*Prionailurus viverrinus*	K	
Gaur	*Bos gaurus*	V	
Hairy nosed otter	*Lutra sumatrana*	K	
Irawaddy dolphin	*Orcaella brevirostris*	K	
Javan rhinoceros	*Rhinoceros sondiacus*	E	
Kouprey	*Bos sauvelli*	E	
Leopard	*Panthera pardus*	-	
Mainland serow	*Capricornis sumatraensis*	I	
Marbled cat	*Felis marmorata*	K	
Marshall's horseshoe bat	*Rhinolophus marshallii*	-	
Northern smooth tailed tree shrew	*Dendrogale murina*	-	
Oriental small clawed otter	*Aonyx cinerea*	K	
Otter civet	*Cynogale bennetti*	-	
Plieated gibbon	*Hylobates pileatus*	E	
Pygmy loris	*Nycticebus pygmaeus*	V	
Smooth coated otter	*Lutra perspicillata*	K	
Stump tailed macaque	*Macaca arctoides*	K	
Sumatran rhinoceros	*Rhinoceros sumatrensis*	E	
Sun bear	*Helarctos malayanus*	V	
Tiger	*Panthera tigris*	E	
Wild buffalo	*Bulabis bulabus*	-	
Reptiles			
Asian giant tortoise	*Manouria emysus*	V	
Batagur	*Batagur baska*	E	
Elongated Tortoise	*Indotestudo elongata*	K	
Estuarine crocodile	*Clocodylus porosus*	V	
Green turtle	*Cheloniamydas*	E	
Hawksbill turtle	*Eretmochelys imbricata*	E	
Impressed tortoise	*Mamouria impressa*	K	
Indian python	*Python molurus*	V	
Siamese crocodile	*Crocodyus siamensis*	E	
Fish			
Asian bony tounge	*Scleropages formosus*	K	
Giant catfish	*Pangasianodon gigas*	V	
Indochina featherback	*Notopterus blanci*	R	
Pla thepa	*Pangasius sanitwongsei*	R	
Silver shark	*Balantiocheilos melanopterus*	I	
Trey trasak	*Probarbus jullieni*	K	
Birds			
Asian dowitcher	*Linmodromus semipalmatus*	R	NT
Asian golden weaver	*Ploceus hypoxanthus*	-	NT
Asian openbill stork	*Anastonus oscitans*	-	NT
Bar billed pitta	*Pitta elliotii*	R	NT
Bengal florican	*Eupodotis bengalensis*	E	EN
Black bellied tern	*Sterna acuticauda*	-	VU

	Scientific Name	IUCN classification	
Black faced spoonbill	*Platalea minor*	E	CR
Black headed ibis	*Threskiornis melanocephalus*	-	NT
Black necker stork	*Ephippiorhynechus asiaticus*	-	*
Blue rumped pitta	*Pitta soror*	-	NT
Chestnut heaed partridge	*Arborophila cambodiana*	R	VU
Coral billed ground cuckoo	*Carpoccyx renauldi*	-	NT
Giant ibis	*Pseudibis gigantica*	R	CR
Greater adjutant stork	*Leptoptilus dubius*	E	EN
Greater spotted eagle	*Aquila clanga*	-	VU
Green peafowl	*Pavo muticua*	V	VU
Grey headed fishing eagle	*Icthyophaga ichthyaetus*	-	NT
Grey headed lapwing	*Vanellus cinereus*	-	NT
Indian skimmer	*Rynchhops albicollis*	-	VU
Lesser adjutant stork	*Leptoptilus javanicus*	V	VU
Long billed vulture	*Gyps indicus*	-	NT
Masked finfoot	*Heliopais personata*	V	VU
Milky stork	*Mycteria cinerea*	V	VU
Nicobar pigeon	*Caloenas nicobarica*	R	NT
Nordmann's greenshank	*Tringa guttifer*	I	EN
Oriental darter	*Anhinga melanogaster*	-	NT
Painted stork	*Mycteria leucocephala*	-	NT
Red heade vulture	*Sarcogyps calvus*	-	NT
Rufous throated fulvetta	*Alcippe rufogularis*	-	NT
Rufous winged buzzard	*Bustastur liventer*	-	NT
Sarus crane	*Gurs antigone*	-	NT
Siamese fireback	*Lophura diardi*	R	VU
Silver oriole	*Oriolus mellianus*	-	VU
Spot billed eagle owl	*Bubo nipalensis*	-	NT
Spot billed pelican	*Pelecanus philippensis*	I	VU
White rumped falcon	*Polihierax insignis*	-	NT
White rumped vulture	*Gyps bengalensis*	-	NT
White shouldered ibis	*Pseudibis davisonii*	I	EN
White winged wood duck	*Cairina scutulata*	V	EN
Wooly necked stork	*Ciconia episcopus*	-	-

Source : National Environmental Action Plan Draft Thematic Working Paper of MOE, April 1996.
CR = critically endangered; E or EN = endangered; V or VU = vulnerable; R = rare; I = indeterminate (but at least E,V,or R); K = insufficiently known; NT = near threatened. (* = E in Asia but not globally because of Australian population.)

IUCN Status Categories

Endangered(E) : Taxa in danger of extinction and whose survival is un likely if the causal factors continue operating.

Vulnerable(V) : Taxa believed likely to move into 'Engangered' category in the near future if the causal factors continue operating.

Rare(R) : Taxa with small world populations that are not present 'Engangered' or 'Vulnerable' but are at risk. These taxa are usually localized within restricted geographical areas or habitats or are thinly scattered over a more extensive range.

Indeterminate(I) : Taxa known to be 'Engangered','Vulnerable' or 'Rare' but where there is not enough information to say which of the three categories is appropriate.

Insufficiently Known(K) : Taxa that are suspected but not definitely known to belong to any of the above categories because of lack of information.

Threatened(T) : Threatened is a general term to denote species which are 'Engangered', 'Vulnerable','Rare','Indeterminate', or 'Insufficiently Known'.

Table B.4.1 The experience on pesticides and insecticides use among 300 farmers in Ksach Kandal district in June, 1997.

1. Have you used pesticides and insecticides ? yes=278(92.7%), no= 22(7.3%)

2. Quesion to "yes"

	from	Friend,	Merchant or Market,	Extension worker,	no answer,	Total
(1)	How did you know it ?	114 (41.0%)	80 (28.8%)	83 (29.8%)	1 (0.4%)	278 (100%)
(2)	Where have you got it ?	5 (1.8%)	271 (97.5%)	0 (0%)	2 (0.7%)	278 (100%)
(3)	Who did you teach how to apply ?	36 (12.9%)	226 (81.3%)	15 (5.4%)	1 (0.4%)	278 (100%)

		~1984	~1989	~1994	~1997	Total
(4)	How long have you used it ?	124 (44.6%)	62 (22.3%)	55 (19.8%)	37 (13.3%)	278 (100%)

		add,	change,	mix,	effective,	Total
(5)	If it is not effective, how do you doing ?	150 (54.0%)	15 (5.4%)	0 (0%)	113 (40.6%)	278 (100%)

(6) Have you ever injured ? yes=150(54.0%), no=128(46.0%), Total=278(100%)

(7) How did you doing that ?

sugar,	medicine,	sugar & medicine,	doctor,	no answer,	Total
41(27.3%),	36(24.0%),	42(28.0%),	16(10.7%),	15(10.0%),	150(100%)

(8) Do you know proper application method ? yes=169(60.8%), no=109(39.2%), Total=278(100%)

(9) Do you want to know proper application method ? yes=120(43.2%), no=158(56.8%), Total=278(100%)

Table B.4.2 Cases of Pesticides and insecticides to use in each villages

	Commune	Puk Reussei		Viheasour	Total
	Village	AnchengLeu	AnchengKrom	Prey Chas	
1)	Azodrin	4 (3.9)	5 (4.5)	- -	9 (2.4)
2)	Cyanimid	41 (39.4)	32 (28.6)	29 (17.6)	102 (26.8)
3)	DDT	3 (2.9)	2 (1.8)	16 (9.7)	21 (5.5)
4)	Fokeb	3 (2.9)	6 (5.3)	3 (1.8)	12 (3.1)
5)	Folidol	49 (47.0)	63 (56.2)	83 (50.3)	195 (51.2)
6)	Mevinphos	4 (3.9)	4 (3.6)	32 (19.4)	40 (10.5)
7)	Phosdrin	- -	-	2 (1.2)	2 (0.5)
	Total(%)	104(100.0)	112(100.0)	165(100.0)	381(100.0)

Table B.4.3 List of Pesticide and Insecticide, used by farmers and selling in the markets in the Study Area.

No.	Trade Name	Effective[1]	WHO[2]	Made in	Apply to
1	Azodrin	A,I	Ib	Vietnam	Rice,Lotus,Maise
2	Cyanimid	u	II	Thailand	Vegetable,Lotus
3	DDT	A,I	II	USA	Vegetable,Beans
4	Diazinon	A,I,N	II	Japan	Vegetable
5	Dithian M45	u	-	Vietnam	-
6	Endrin	A,I	Ib	Thailand	Vegetable V
7	Fillitox 70S	A,I	Ib	Vietnam	-
8	Folidol E605	A,I	Ia	Thailand	Rice,Vegetable,Lotus
9	Fokeb	u	-	Thailand	Vegetable
10	Furadan 3H	I	-	VietNam	-
11	Hopsan 75	u	Ib	Vietnam	-
12	Kemocraft	I	-	Thailand	Rice, Vegetable
13	Methamidophos	I	-	China	Rice, Cotton
14	Methaphos 40ND	A,I	Ia	Vietnam	Vegetable
15	Methomyl	I	-	Thailand	Rice, Vegetable
16	Mevinphos	A,I	Ia	Thailand	Vegetable
17	Monitor 70DD	A,I	Ib	Vietnam	Vegetable
18	Padan 95SP	A,I	II	Thailand	Vegetable
19	Phosdrin	A,I	Ia	Vietnam	Vegetable
20	Thiodan 35ND	A,I	II	Vietnam	Vegetable
21	Thuricide H.P	I	-	Thailand	Rice, Vegetable
22	Vibasu 5ND	u	-	Vietnam	-
23	Vibam 5H	u	-	Vietnam	-
24	Vicidi M50D	A,I	II	Vietnam	Beans
25	Visher 25ND	u	-	Vietnam	Vegetable,Beans
26	Zinc Phosphide	R	Ib	-	Rats
27	2-4D 720EC	H	II	VietNam	-

Note :

1) Effective for : A = acarid, I = insect, N = nematode, R = rodent, H = herb, u = unidentified.

2) WHO : WHO Classification ; Ia = Extremely hazardous, Ib = Highly hazardous, II = Moderately hazardous

Table B.4.4 List of firewood trees and using percentage in each village in the study area in Ksach Kandal District

CommuneName / Village Name / Local Name	Vihearsour Prei Chas Families(%)	Puk reussei Ancheng Krom Families(%)	Puk reussei Ancheng Leu Families(%)	Total Families(%)	Remarks Scientific Name
1 Ampil Barang	- -	3 (1.2)	- -	3 (0.4)	
2 Ampil Teuk	- -	23 (9.2)	- -	23 (3.5)	Cynometra
3 Angchang	12 (5.2)	5 (2.0)	- -	17 (3.2)	Gmelina asiatica
4 Anger Dey	- -	11 (4.4)	3 (1.7)	14 (2.1)	
6 Banla Yuon	7 (3.0)	27 (10.8)	11 (6.1)	45 (6.8)	Mimosa pigra
7 Chamneang	8 (3.5)	- -	- -	8 (1.2)	
8 Chrey	9 (3.9)	- -	- -	9 (1.4)	
9 Coconat trees	- -	12 (4.8)	7 (3.9)	19 (2.9)	
12 Ktom	3 (1.3)	- -	- -	3 (0.4)	Stephegyene
13 Ngongea	4 (1.7)	- -	- -	4 (0.6)	
14 PhnomPhneng	17 (7.4)	4 (1.6)	7 (3.9)	28 (4.2)	Hyme.walichii
15 Probouy	28 (12.2)	9 (3.6)	6 (3.3)	43 (6.5)	Croton caudatus
16 Reang	53 (23.0)	59 (23.5)	60 (33.1)	172 (26.0)	Barr.micrantha
17 Sangker	30 (13.0)	11 (4.4)	6 (3.3)	47 (7.1)	Com.quadrangulare
18 Snay	7 (3.0)	- -	- -	7 (1.1)	Grewia sinuata
20 Mango tree	- -	- -	6 (3.3)	6 (0.9)	
21 Tean Prey	4 (1.7)	- -	- -	4 (0.6)	Vitex Holoadenon
23 Trees skin	- -	14 (5.6)	15 (8.3)	29 (4.4)	
24 Troas	35 (15.2)	64 (25.5)	56 (30.9)	155 (23.4)	Com.trifoliatum
25 Trosek	13 (5.7)	9 (3.6)	- -	22 (3.3)	Pel.ferrungineum
Total	230(100.0)	251(100.0)	181(100.0)	662(100.0)	

Note : Hyme.walichii = Hymenocardia, Barr.micrantha = Barringtonia micrantha, Com.quadrangulare = Comretum quadrangulare, Com.trifoliatum = Comretum trifoliatum Pel.ferrungineum = Peltophorum ferrungineum

Table B.4.5 List of Plants in the study area in Ksach Kandal District

No	Local Name	Scientific Name	Finding in here	Growing place	Planting by seeds	Use for mainly
1	Smav bekkebal	Echinocloacrus galli	easy	anywhere	easy	-
2	Smav pukbangkang	Digitaria ciliaris	easy	anywhere	easy	-
3	Smav kravanchruk	Cyperus rodentus	easy	anywhere	-	-
4	Smav chanchountuk	Cynodon dactylon	easy	floodplain	easy	-
5	Smav tranotantung	-	easy	floodplain	no	-
6	Smav barang	-	easy	anywhere	easy	-
7	Smav choengkras	Eleusine indica	easy	anywhere	easy	-
8	Smav kantray	-	-	anywhere	easy	-
9	Smav achkok	-	-	swamp	easy	-
10	Phlong	-	-	swamp	easy	-
11	Kak chrung	Cyperus irria	easy	-	-	furniture
12	Kak moul	Cyperus difformis	easy	floodplain	easy	furniture
13	Srange	Oryza sativalvar	easy	anywhere	easy	-
14	Treng	-	easy	anywhere	-	-
15	Babos	-	easy	anywhere	-	-
16	Tapang he	Sphenochlea zeylanica	easy	anywhere	-	-
17	Vataak	Impomoca chryscides	easy	anywhere	easy	-
18	Vaphom	Parameria glendulifura	easy	anywhere	easy	-
19	Vaandat trakuot	-	-	floodplain	no	-
20	Vapreng	-	easy	anywhere	easy	-
21	Vatrey	-	easy	anywhere	no	-
22	Vaprash	Quisqualis densiflora	easy	anywhere	easy	medicine
23	Vasalong	-	-	-	-	-
24	Vakacheap	-	-	-	-	-
25	Vakambor	-	easy	anywhere	easy	-
26	Savob	-	easy	anywhere	-	building
27	Sanor	Sasbania aquatica	easy	floodplain	-	-
28	Komping puoy	Jussiaca repens	easy	floodplain	-	-
29	Saray	-	easy	floodplain	-	-
30	Pralit	Nymphaealotus	-	floodplain	-	-
31	Rumchang	Nymphaeastellata	easy	floodplain	-	-
32	Chhuk	Nelumbo nucifera	dfclt	floodplain	easy	-
33	Slab chrava	Ottelia Japonica	easy	floodplain	-	-
34	Trakuon	Impomea aquatica	-	floodplain	easy	-
35	Trakuon trakek	-	easy	anywhere	easy	-
36	Krachap	Pentapetes phoenicea	easy	floodplain	-	-
37	Kamplok	Eichhomia crassipes	easy	floodplain	-	-
38	Trakeat	Monochoria hasteafolia	easy	floodplain	-	-
39	Chrach	Monochoria vaginalis	dfclt	floodplain	-	-
40	Chark	Nipa fruitcans	-	floodplain	-	-
41	Travprey	-	easy	floodplain	-	-
42	Chantul phnom	-	easy	anywhere	-	-
43	Reang	Barringtonia	easy	anywhere	easy	firewood
44	Troas	Combretum trifoliatum	easy	anywhere	easy	firewood
45	Kravan tuk	-	-	-	-	firewood

No	Local Name	Scientific Name	Finding in here	Growing place	Planting by seeds	Use for mainly
46	Ktum	Stephegyene	easy	floodplain	dfclt	firewood
47	Khnay mon	–	–	floodplain	–	firewood
48	Taour	Terminalia	easy	floodplain	–	–
49	Tasek	Petophrum ferrungineum	–	floodplain	easy	building
50	Thmenhtrey	Bridelia pedicellata	easy	anywhere	easy	firewood
51	Treash	–	dfclt	floodplain	–	–
52	Banla yuon	Mimosa pigra	easy	anywhere	easy	–
53	Prabuoy	Croton caudatus	easy	floodplain	easy	firewood
54	Krapenh nhi	Phyllatus	easy	river side	–	medicine
55	Taloem andoek	–	easy	anywhere	easy	–
56	Char	Butea frondosa	dfclt	anywhere	easy	dye, rope
57	Snay	Grewia sinuata	easy	anywhere	easy	medicine
58	Sandan	Garcinia	dfclt	floodplain	easy	–
59	Anhchanh	Gmelina asiatica	easy	floodplain	easy	–
60	Phnomphneng	Hymenocardia walichii	easy	floodplain	easy	–
61	Bakdot	–	–	–	–	–
62	Banla saet	Acasia spiralis	easy	floodplain	easy	firewood
63	Sangke	Combretum quadrangulare	easy	anywhere	easy	bld,frwd
64	Longeang	Cratoxylon formosum	dfclt	floodplain	easy	firewood
65	Mean prey	Euphobia cambodiana	easy	floodplain	easy	–
66	Chrakeng	Coccocena anisopodum	dfclt	floodplain	easy	–
67	Nhor	Morinda citrifolia	easy	floodplain	–	dye,mdcn
68	Prakrab	–	–	anywhere	easy	medicine
69	Lahong kanhe	Ricinis communis	easy	river side	easy	firewood
70	Kapeng he	–	–	floodplain	easy	–
71	Slak	–	–	river side	easy	medicine
72	Kadol	Sarcocephalus cordatus	–	anywhere	easy	bld,frwd
73	Kandol	Caraya	–	anywhere	easy	firewood
74	Chamreak	Albizzia lebekkoides	–	anywhere	easy	bld,frwd
75	Dankeab kdam	Antidesma ghaesombilla	–	floodplain	easy	mdcn,frwd
76	Tunlear	Cratevabuch hamvar	dfclt	floodplain	easy	mdcn,frwd
77	Kror	–	–	floodplain	easy	firewood
78	Tuntreang khet	Eupatorium	–	anywhere	easy	–
79	Var daunprash	Quisqualis densiflora	–	–	–	medicine
80	Var tadet	–	–	anywhere	easy	
81	Mukchhneang	–	–	river side	easy	medicine
82	Puos ambeng	–	–	floodplain	easy	medicine
83	Phnek preap	Breynia rhamnoides	easy	anywhere	easy	firewood

Note : " – " marking means that it is an unidentified.
bld = housing material
mdcn = some part of a plant is used for a traditional medicine, such as seeds, leave, roots, fruits, and so on.

Table B.4.6 List of Waterfowl in the study area in Ksach Kandal District

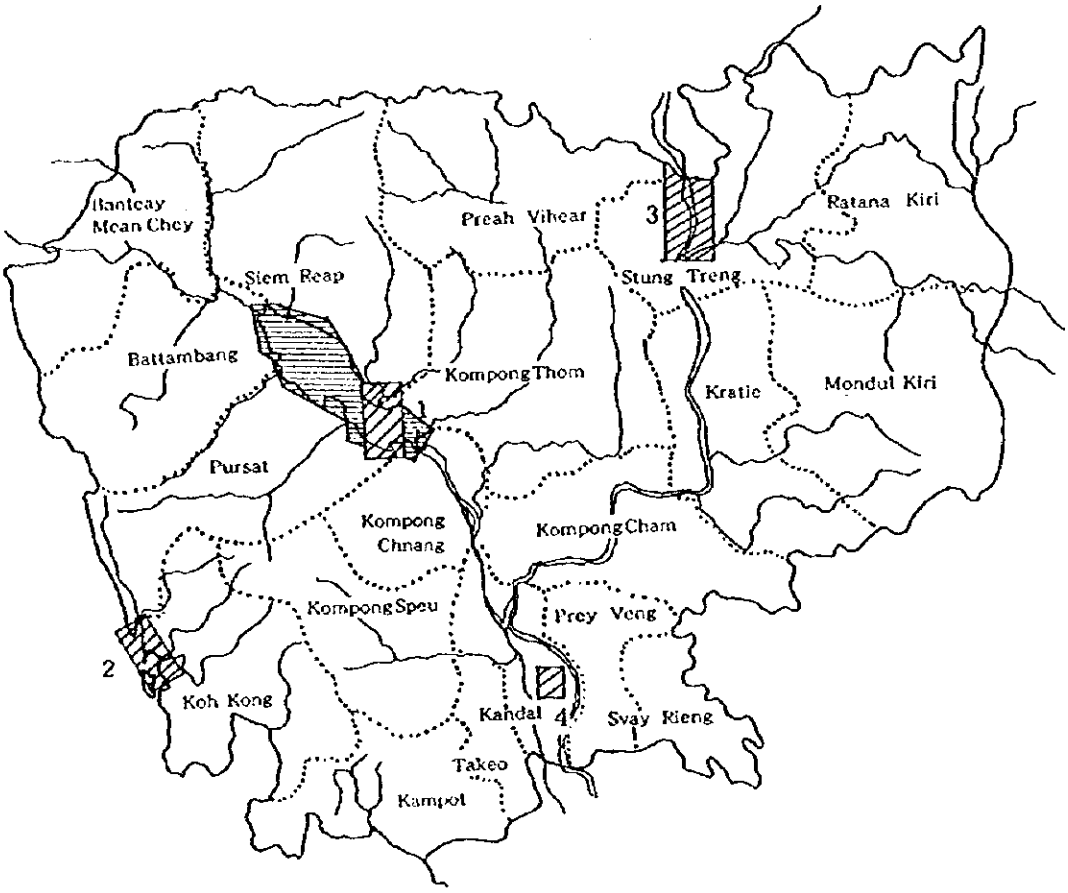
No	Local Name	Scientific Name	Finding in here	Size(cm)	Colour	Feed
1	Smogn	Anhinga melanogasier	-	50	grey	fish
2	Krosa prophes	Ardea cinerea	dfclt	35	grey	fish
3	Krosa prophes slap	Ardea Sumatrana	dfclt	35	greywhite	fish
4	Kok kron thom	Egretta alda	-	32	white	fish
5	Kok kron toch	Egretta garzetta	dfclt	30	white	fish
6	Kok kor	Bubuleus ibis	dfclt	30	white	fish
7	Kok krok	Ardeola bacchus	easy	29	grey	fish
8	Kok roneam	Egretta sacra	easy	28	greywhite	fish
9	Tung prophes	Pelecanus philippensis	dfclt	45	greywhite	fish
10	Tung thom sor	Pelecanus onocrotalus	dfclt	45	white	fish
11	Kaek teuk	Phalacrocorax carba	no	32	black	fish
12	Kaek teuk toch	Phalacrocorax niga	easy	30	black	fish
13	Tea prey	Anas acuta	easy	35	greywhite	fish
14	Proveuk thom	Dandrocygna javanica	easy	30	black	fish
15	Proveuk toch	Anas crecca	easy	28	grey	fish
16	Proveuk	Nettapus pulchellus	dfclt	28	greyblack	fish
17	Klom	Fulica atra	dfclt	26	grey	fish
18	Moin teuk thom	Gallicrex cinecea	-	30	brown	fish
19	Moin teuk toch	Porphyrio edwarsi	dfclt	28	grey	fish
20	Krodevich	Sarcofranus indicus	dfclt	28	grey	fish
21	Kvaik	Scolopax rusticola	-	30	blackgrey	fish
22	Tom	Amauromis Phocnicurus	no	45	whitegrey	fish
23	Aot thom	-	easy	35	redblack	plant
24	Aot sbov	-	easy	30	brown	plant
25	Roneal	Mycteria leucocephala	dfclt	35	whitegrey	fish
26	Kreal	Grus antigone	no	45	grey	fish
27	Trodok thom	Leptoptilos Dubius	no	38	blackgrey	fish
28	Trodok toch	Leptoptilos javanicus	no	35	-	fish
29	Tituy	Bubobubo	dfclt	35	grey	insect
30	Kleng srak	Strix flammea	dfclt	25	darkbrown	insect
31	Smorng kor veng	Oriental darter*	no	45	grey	fish

Note : * = English name, Anhinga sp.
" - " marking means that it is unidentified yet.

Table B.4.7 List of Fish in the study area in Ksach Kandal District

No	Local Name	Scientific Name	Finding in here	Size(cm)	Habitat	Use for
1	Trey ros	Channa marulius	easy	70	lk	cm,lm
2	Trey damrey	Oxyeleotris marmorata	dfclt	35	anywhere	exp,cm,lm
3	Trey sanday	Wallago attu	dfclt	80	rv,mkg	cm,lm
4	Trey chhkok	Cyclocheilichthys enoplos	easy	50	lk,rv,mkg	cm,lm
5	Trey kes	Micronema apogon, M. bleckeri	easy	40	lk,mkg	exp,cm,lm
6	Trey chhlang	Mystus nemurus	easy	50	lk,rv,mkg	cm,lm
7	Trey kanchos	Mystus wolfi	easy	15	lk,rv,mkg	cm,lm
8	Trey kromorm	Ompokbimaculatus	easy	25	-	cm,lm
9	Trey andeing roeung	Clarius batrachus	easy	40	lk,swp	exp,cm,lm
10	Trey andeing toum	Clarius meladerma	easy	35	lk,swp	exp,cm,lm
11	Trey pra	Pangasius djambal	easy	60	mkg,rv	exp,cm,lm
12	Trey pra kchav	Pangasius bocourtia	easy	50	rv,mkg	exp,cm,lm
13	Trey chhviet	Pangasius macronema	easy	18	lk,rv,mkg	cm,lm
14	Trey klang hay	Bebodonticchthys dinema	easy	60	lk,mkg	exp,cm,lm
15	Trey khman	Hampala dispar	easy	35	lk,rv,mkg	cm,lm
16	Trey chhpin	Hypsibarbus lagleri rainboth	easy	35	lk,rv,mkg	cm,lm
17	Trey chrakeing	Puntioplites faicifer	easy	30	lk,rv,mkg	cm,lm
18	Trey kaek	Morulius chrysophekadion	easy	60	lk,mkg	cm,lm
19	Trey krum	Osteochilus melanopleurus	easy	40	lk,rv,mkg	cm,lm
20	Trey slat	Notopterus	easy	30	lk,rv	cm,lm
21	Trey changwa	Opsarius koratensis	easy	8	anywhere	cm,lm,sc
22	Trey changwa mool	Rasbora aurotaenia	easy	15	lk,rv,mkg	cm,lm,sc
23	Trey linh	Thynmichthys thynnoides	easy	16	lk,rv,mkg	cm,lm
24	Trey riel	Henicorhynchus siamensis	easy	17	lk,rv,mkg	exp,cm,sc
25	Trey chdaur	Channa micropeltes	dfclt	70	lk,mkg	exp,cm,lm
26	Trey ampiltum	Systomus orphoides	easy	20	lk,rv	cm,lm
27	Trey koul reang	Catlocarpio siemensis	dfclt	250	lk,mkg	exp,cm,lm
28	Trey kantrab	Pristolepis fasciata	easy	20	lk	cm,lm,sc
29	Trey kanthor	Trichodaster pectoralis	dfclt	20	lk	cm,lm
30	Trey kanchanh chras	Pseudambasis notatus	easy	5	lk,rv,mkg	cm,lm,sc
31	Trey kamplean phluk	Trichogaster microlepis	easy	15	lk,swp	cm,lm,sc
32	Trey kambot chramos	Sikukia gudgeri	easy	18	lk,mkg	cm,lm,sc
33	Trey kahe	Bardodu Schwanefeldi	dfclt	30	lk,mkg	cm,lm
34	Trey khnong veng	Dangila lineata	easy	18	anywhere	cm,lm,sc
35	Trey phtong	Xenentodon cancila	easy	20	anywhere	cm,lm,sc

Note : Habitat ; lk=lake, rv=river, mkg=Mekongriver, swp=swamp
Use for ; cm=central market, lm=local market, exp=export, sc=fish sauce



1 Boeng Chhma and Associated River Systems, and Boeng Tonle Sap Floodplain

2 Kaoh Kapik and Associated Islets

3 Middle Stretches of Mekong River North of Stung Treng

4 Bassac Marshes

Figure B.2.1 The Areas of Field and Aerial Surveys to Identify Wetlands International Importance

Source : Ministry of Environment

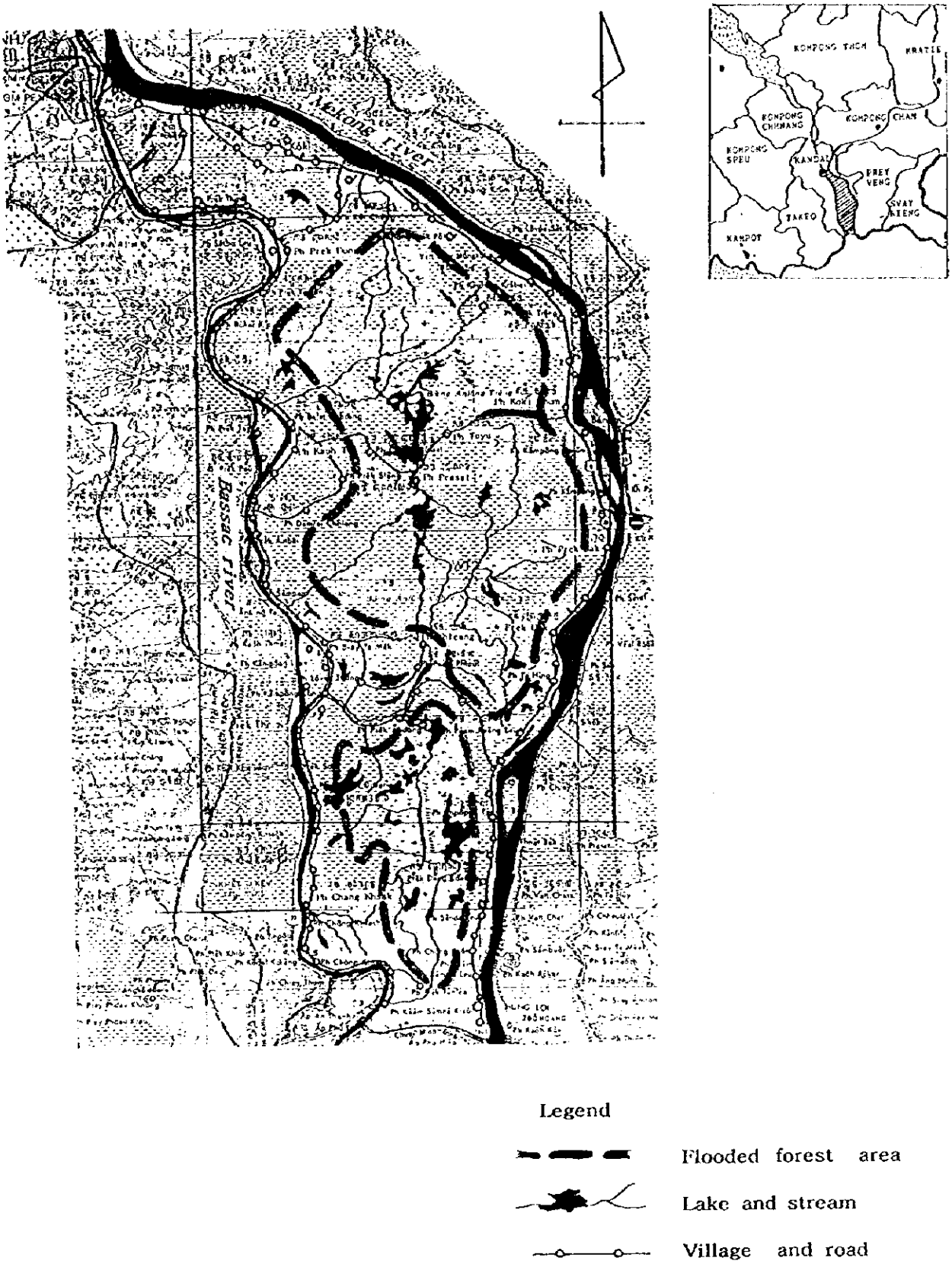
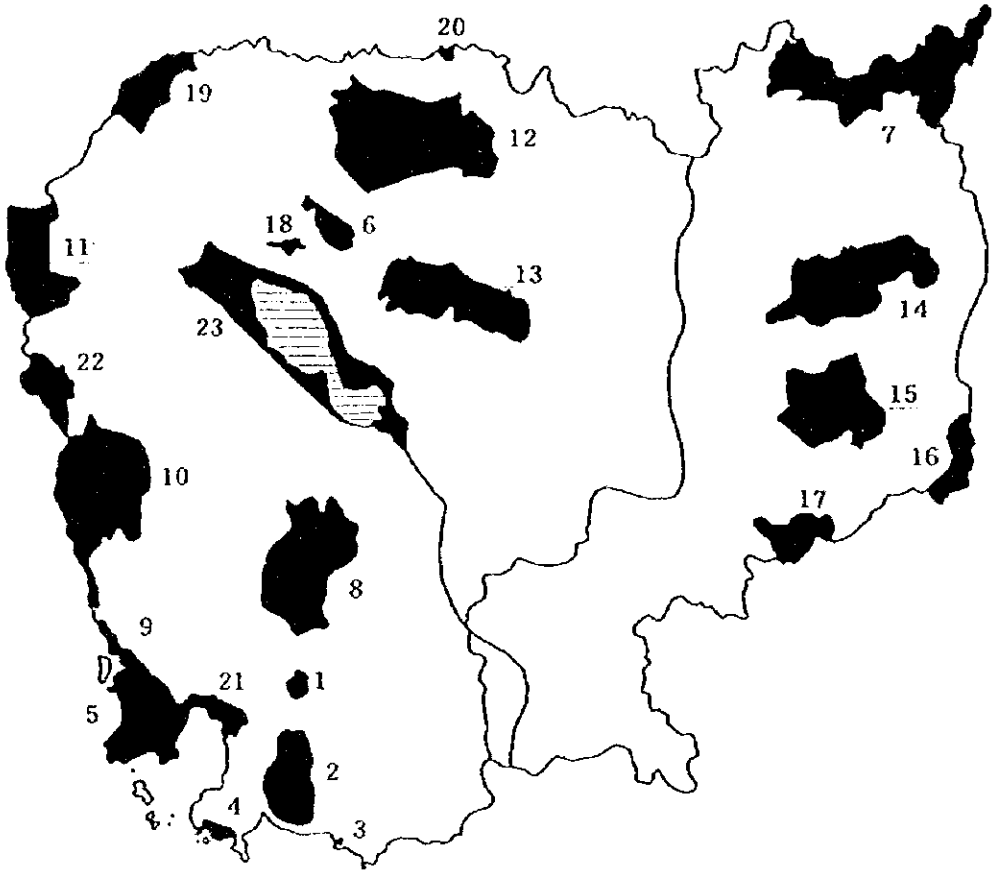


Figure B.2.2 Main Flooded Forest Area in the Bassac Marshes Area

Sources : 1992/93 Land Cover Map of Kandal Province in Cambodia Land Cover Atlas



1. National Parks
   1. Kinriom
   2. Phnom Bokor
   3. Kep
   4. Ream
   5. Botum Sakor
   6. Phnom Kulen
   7. Virachey

2. Wildlife Sanctuaries
   8. Aural
   9. Peam Krasop
   10. Phnom Samkos
   11. Roniem Daun Sam
   12. Kulen Promtep
   13. Beng Per
   14. Lomphat
   15. Phnom Prich
   16. Phnom Nam Lyr
   17. Snoul

3. Protected Landscapes
   18. Angkor
   19. Banteay Chmar
   20. Preaah Vihear

4. Multiple Use Areas
   21. Dong Peng
   22. Samlaut
   23. Tonle Sap

Figure B.2.3 Designated Areas as Protected Area

Source : Ministry of Environment

APPENDIX C

Hydrology

C METEOROLOGY and HYDROLOGY

Part II Feasibility Study

Feasibility Study - Boeng Phtea Area

List of Figures

List of Tables

C1 INTRODUCTION

C1.1 General

C1.1.1 Geology

The lower Mekong delta in Cambodia, including the Tonle Sap Lake, was a part of the sea during the initial Alluvial epoch, about 6,000 years ago. As the sea retreated and the depth became shallower, the sediments were deposited at around the granitic and volcanic knolls, especially around Kompong Chhnang where the knolls were the nuclei of sand dune formation. The sediments were from the erosion in the gorges of the upper Mekong which started during the Tertiary Period. The activity of sediment deposition in the lower Mekong delta is still evident today and is aggravated by the heavy clearing of forest around the Tonle Sap Lake, resulting in diminishing lake surface area and depth.

Much of the delta is underlain by the diluvium and alluvium layers, a formation of fine sand, slit and clay deposit. Boring data along Mekong, road improvement and well construction projects have shown that the sand layer (fine to coarse) below clay and silt top layers is about 20-40m. Below the sand layer is the weathered sandstone and/or mudstone layer

C1.1.2 Topography

The central plain, in which the study area is located, is surrounded by the Cardamon and Elephant mountain chains-1,000 to 1,800m- to the west and southwest, the catchment of Tonle Sap Lake to the north and the low -40 to 200m- and high -400m-1,000m- undulating plateau to the northeast. The study area is generally below 30m elevation, gradating in altitude from north and west towards south and east: The edge of the plateau in the north and west is about 30-35m, the confluence of Mekong and Tonle Sap river 10m, Takeo 8m and Svay Rieng 3m. A large part of the plain is below 10m in elevation. The plain can also be divided into river banks or levees, the lowland between the levee and the terrace, and the upper terraces

C1.2 Objectives

The objectives of present hydrological analysis are to provide the basic information needed in the planning and design of irrigation and drainage improvement in the flooded plain of Lower Mekong Delta. The topics covered are:

- meteorological conditions
- rainfall analysis and estimation of effective and design rainfall
- estimation of discharge in Mekong, Bassac and Tonle Sap rivers
- water level analysis and estimation of design flood levels
- estimation of inundated area and flood overtopping locations
- water balance along Mekong river
- water quality survey

C1.3 Data availability

Cambodia rejoined the Mekong River Commission only recently. Studies and review on reactivation and improvement of the hydrometeorological network in Cambodia have already been conducted and implementations of improvement projects are underway, with assistance from NGO's and MRC. Recent data record has been compiled into the database - the Hydrological Year Books. However, large gap exists in the data record due to internal instability in the seventies and older data are scarce.

Mean monthly values of data record in the fifties and sixties are found in some reports. Daily data for these periods, believed to be long, uninterrupted and reliable, for detail planning is not easily available. Much of the data might have been lost or destroyed during the internecine war.

Data for this study were collected mainly from the Pochentong Meteorological Station and Hydrological Department of GDIMH, supplemented with data from National Mekong Secretariat and Hydrological Year Books. The limited data collected were only adequate to give an approximate assessment of the situations.

C2 METEOROLOGY

C2.1 General description

The climate of Cambodia is basically tropical monsoonal, with distinct wet and dry seasons. The climate of the study area, with distinctly marked dry and wet seasons intervened by short periods of transitional instability, is strongly influenced and dominated by the tropical monsoons: The wet season, with frequent and heavy rainfall brought by the moisture-laden air of the southwest monsoon drawn landward from the Gulf of Thailand, lasts from mid-May to November; and the dry season, under the influence of relatively drier and cooler northeast monsoon air, lasts from December to April.

The climate of the study area falls into the category of tropical savanna climate by Koppen climatic zone. The study area, comprising a large part of the lower Mekong basin, is relatively drier with average rainfall of about 1,000 mm in the south and 1,600 mm in the north, coming mainly from southwest monsoon. Typically in June or July, due to high-altitude anticyclonic circulation, there may be short period of consecutive dry days (10-15 days) which causes farmers to delay cultivation.

C2.2 Data Availability

Figure C2.1 shows the existing observation stations and synoptic posts in the study area. Table C2.1 shows the availability of meteorological data of the respective stations/posts. As evident from the data record, observation had been interrupted during the Pol Pot regime (1971-1980) and internal instability.

Most of the data exist in manuscript form. Monthly data for the basic meteorological elements are available at Pochentong Meteorological Station. Though incomplete, data of some of the main stations are also available at Pochentong.

C2.3 Meteorological Data

Figure C2.2 and Table C2.2 show the basic meteorological data of Pochentong Station (Phnom Penh). Mean monthly maximum and minimum temperature are similar to the values obtained over a much longer period (Figure C2.3).

Since spatial variation of most of the meteorological elements is small and data record available at Pochentong is relatively long and reliable, like in most studies in the periphery of Phnom Penh, the mean values of Pochentong are adopted to interpret climatic conditions of the study area.

Mean monthly maximum temperature ranges from 30°C in December to 34.6°C in April, minimum temperature from 21.1°C to 25.8°C and mean temperature from 25°C to 29.7°C, relative humidity from 67% in March to 84% in September, monthly evaporation from 108.8 mm in September to 227.5 mm in March and sunshine from 173.9 hr in August to 279.7 hr in February.

C2.3.1 Mean Monthly Data

Mean monthly and annual rainfall at Kratie, Kompong Cham, Pochentong, Prey Veng and Takeo are shown in Figure C2.4 to C2.8. The monthly mean rainfall charts show that rainfall happens sooner in the north and together with the peak shifts southward towards the end of season: The peak in Kratie happens in August/September, Kompong Cham and Phnom Penh in September, Prey Veng in September/October and Takeo in October. Annual rainfall charts show that annual rainfall varies widely from year to year.

Mean monthly values for maximum and minimum temperature, relative humidity, wind speed, rainfall and evapotranspiration and sunshine hours for Kratie, Kompong Cham and Pochentong (Phnom Penh), adopted from "Irrigation Rehabilitation Study in Cambodia", are shown in Figure C2.10 - Figure C2.11 and Table C2.3.

C2.3.2 Mean Annual and Design Rainfall

Mean annual rainfall and design rainfall for 1/10 return period of exceedance and non-exceedance at the respective stations are shown in Figure C2.9.

C2.3.3 Isohyetal Map

The isohyetal map shown in Figure C2.12 was adopted from "Irrigation Rehabilitation Study in Cambodia". As can be seen from the map, a major part of the Study Area lies within the 1,400mm isohyetal line and relatively dry compared with the hilly parts of the country.

C2.3.4 Effective Rainfall

Effective rainfall for paddy field is assumed to be 80% of rainfall greater than 5mm/day and less than or equal to 80mm/day, or 4mm/day to 64mm/day. Effective rainfall for the respective stations are shown in Table C2.4. From the table it is clear that effective rainfall of the Study Area is about 53%~o 55% of annual rainfall.

C3 HYDROLOGY

C3.1 River System

C3.1.1 The Mekong River

The Mekong river is 4,200km long from the Tibet Plateau to the South China Sea. It is the 11th longest river [1], has the 8th largest annual discharge (475,000MCM) and 22nd largest drainage basin[2] in the world (Ven Te Chow, 1964). The Mekong river (also called Tonle Thom in Cambodian language) originates in China (at some 5,000m in Tanghla Shan Mountains), flows through Myanmar, Laos and Thailand before entering Cambodia. After the Khone Fall at the border with Laos and a series of rapids further downstream in Kratie province, the Mekong is wider and less turbulent. Inside Cambodia the Mekong river, traversing from north to south, together with Tonle Sap and Bassac rivers, form the main river system which drains 3/4 of the country's land area and thus dominates the hydrology of the country.

C3.1.2 River System in Cambodia

River system in Cambodia is in a somewhat distorted "K" shape; the two reaches of Mekong river before Phnom Penh (the Upper and Middle Tonle Thom) and after Phnom Penh (the Lower Tonle Thom), Tonle Sap river and Bassac river, confluencing at Chaktomuk and forming the four arms of the "K" shape river system. Mekong river (Upper Tonle Thom, from Laos border to Kratie) flows southward until Kratie, southwestward (Middle Tonle Thom, from Kratie to Phnom Penh) before Phnom Penh and southeast after, and southward again after Neak Luong (Lower Tonle Thom, from Phnom Penh to Viet Nam border). Tonle Sap river, the outlet for the basin of the Tonle Sap Lake (the Great Lake) in the northwest, flows southeastward before joining Mekong at Chaktomuk (Phnom Penh). The Bassac river, starting from Chaktomuk and flowing almost parallel to the lower arm of Mekong within Cambodia, flow directly into the Mekong delta complex in Viet Nam and into the South China Sea.

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[1] the 8th, 4,425km, Royal Geography Association, April, 1995.

[2] 21st, 795,000km^2

C3.1.3 River System in the Study Area

The study area is drained by the two arms of Mekong (Middle Tonle Thom, about 100km long, 0.8-7km wide, 30-50m deep and Lower Tonle Thom, 95km long, 0.9-4km wide), the lower reaches of Tonle Sap river (33km long, from Prek Kdam to Phnom Penh) and Bassac river (83km long, 0.4-2.5km wide). The bed elevation of Mekong river is below Hatien M.S.L. from around Kompong Cham. The main tributaries are Prek Te, Prek Chhlong, Tonle Toch (100km long & 30-50m wide), Stung Prek Thnot, Stung Slakou and Stung Takeo (Figure C3.1, Catchment of Mainstream and Tributaries in the study area). Except for Tonle Toch which diverts some of the flood water of Mekong at Peam Praphnouh (9km south of Kompong Cham) during rainy season, the other tributaries flow out from relative higher ground and have catchment of their own.

C3.1.4 Cambodia Words for River System

The characteristic of the river system is more easily deciphered with the help of some knowledge on the following Cambodian words used in naming the system as they best describe the natural nuances of the actual situations of the rivers.

- TONLE is a large river and only about 4 rivers are given the name: Tonle Sap (meaning fresh and not salty tonle), Tonle Thom (the other name for Mekong, meaning large tonle), Tonle Bassac and Tonle Toch (meaning small tonle)
- STUNG is a relatively large perennial river flowing out from the mountains into Tonle Sap Lake, Tonle Sap, Mekong, Bassac rivers, and also those flow directly into the coast of Gulf of Thailand in the southwest (outside Mekong basin). Around Tonle Sap Lake the stungs flowing into the lake, with relatively few tributaries, are like the spokes of wheel, radiating from the lake. Except for a few stungs such as Stung Seam Reap and Stung Rolous, most of them are natural rivers. Except for Stung Sen, the lower reaches of stung in the flood plain, normally with few meanders, are usually subject to overtopping during wet season. The upper reaches in the higher elevation, usually with many meanders, are seldom overtopped in wet season and water level can be several meters below the bank during dry season.
- O is the name given to the smaller tributaries of stung or tonle. They are usually natural channels originating in the mountains and dry up from January to May (dry season).
- PREK, like O, is smaller than Stung. They are usually man-made channels and subject to reverse flow (May to September) from the Great Lake or rivers such as Mekong, Tonle Sap and Bassac. Since the bed of Prek is normally set higher than the initial flood stage of the stung and tonle, only muddy water of higher flood stage is channeled to swamps and low-lying lands to enhance sedimentation. Some preks are ephemeral and cease to flow

in the dry months.

- BOENG is the flood plain or lake between the levee of large rivers and the terrace. The major part of flood plain is normally dry during dry season and inundated by flood during rainy season.
- PEAM is the word given to the confluence point of rivers and is quite commonly found in the names of place.
- MOR TONLE is the natural levee and bank along the rivers.
- ANGTUK is a reservoir built to store water for irrigation and home use.
- TRAPEANG is a muddy water pond. Some are man-made. It is usually not fit for drinking and cooking purpose. In countryside, it is the main source of water for home use.
- SRAS is a dugout/man-made pond to store water for drinking and home use, and is commonly found in monastery.

C3.2 Hydrological Stations and Data Availability

3.2.1 Hydrological Stations

Figure C3.2 shows the locations of the 8 existing hydrological observation stations in the Study Area. All of the stations are located along Mekong, Bassac and Tonle Sap rivers. Observation for the major tributaries is scarce.

C3.2.2 Data Availability

Table C3.1 shows data availability of the 8 hydrological stations in the Study Area. Except for Koh Khel, all the other stations started observation in the sixties. Observation at Koh Khel was started in 1991. As can be seen from the table, water level data are available for most of the stations. Discharge data are scarce. Discharge data for the recent years are available at Chrouy Changvar only. Like meteorological observation, hydrological observation was also disrupted by internal instability in '70s.

C3.3 Hydrological Features of River System

C3.3.1 Water Level at the Gauging Stations

Average monthly flood stage (water level) at the stations along Mekong, Tonle Sap and Bassac rivers in the study area were calculated and plotted to delineate the characteristics of flood stages (Figure C3.4, Table C3.2). The monthly values were creamed from whatever daily data exit in the data record in GDIMH. Due to inconsistency and crisscrossing of record, the period taken differs from station to station, a problem difficult to be resolved. Also, only single (the existing zero gauge elevation above or below Hatien Mean Sea Level) zero gauge elevation of the respective stations was used. This could cause some errors, especially for old data since they could have been observed under a different zero gauge height.

Figure C3.5 shows the yearly plot of the observed data and Figure C3.6 shows the fluctuation of water level at the observation stations. Figure C3.7 shows the annual maximum, minimum and mean water level for the observed period.

Except for Prek Kdam along Tonle Sap river, the water level of all other stations follow similar trend of rise and fall: with that of Kratie being the highest, follows by Kompong Cham, Chrouy Changvar, Chaktomuk and Neak Luong. Water level starts to rise in May, peaks in September and continues to level off until April. Since the stations are quite close to each other, the difference in water level between Chrouy Changvar and Chaktomuk is small. For the months (November to April) where water level of Tonle Sap Lake is on the decline, water level of Chaktomuk is higher than that of Chrouy Changvar, though very small in magnitude. The difference in water level between Prek Kdam and Chaktomuk is generally small. From October to June, the period when Tonle Sap Lake is emptying the flood water from its catchment and that of reverse flow stored during rainy season, the water level of Prek Kdam is higher than that of Chaktomuk. One other fact of yearly water level fluctuation that warrant attention is the double peaks seen in most of the stations. The first peak usually comes in June as a result of snow melting in the Tibetan plateau. This water from melting snow, which brings about higher rising rates of water level, seldom causes water level to cross the threshold flood level. The second peak, resulting mainly from rainfall brought by the southwest monsoon in the upstream basin of Mekong and inside Cambodia, normally happens in September and could cause enormous expanse of water and huge area of inundation over a period of 3-6 months.
See below for the mean highest monthly rising and falling rate (m/day) of water level, average, maximum and minimum range (difference of the highest and lowest water level) of fluctuation

and threshold water level of colmatage canals around the hydrological stations in the study area. River water starts to flow into the colmatage canals when water level rises above the respective threshold levels.

Average rising and falling rate, average, max & min range, and threshold water level Unit: m, m/day

Station	Rising trend		Falling trend		Range of fluctuation			Threshold
	rate	month	rate	month	Average	Max	Min	Level
Kratie	0.16	Jun	0.15	Oct	14.08	18.85	12.4	14
					17.96-3.89	1939	1988	
Kompong Cham	0.14	Jun	0.1	Oct	11.63	13.58	10.84	10
			0.1	Nov	12.61-0.99	1966	1989	
Chrouy Changvar	0.07	Jun	0.07	Nov	7.70	9.27	5.48	7
	0.06	Jul			8.55-0.85	1966	1988	
	0.07	Aug						
Chaktomuk	0.07	Jun	0.07	Nov	8.49	9.29	6.56	7
	0.06	Jul			9.12-0.63	1966	1988	
	0.07	Aug						
Neak Luong	0.05	Jun	0.06	Nov	5.74	7.39	5.05	5
		Jul	0.06		6.38-0.65	1966	1989	
Koh Khel	0.06	Jun	0.05	Nov	5.46	6.1	5.33	5
	0.07	Jul	0.04	Dec	6.16-0.7	1991	1993	
Prek Kdam	0.07	Jun	0.07	Nov	7.8	9.45	6.36	7
	0.07	Jul	0.06	Dec	8.68-0.88	1961	1988	
	0.06	Aug						

Note The figures below max and min range show the year of occurrence. And those below average range show the high and low level of average range. River water starts to flow into the colmatage canals when water level rises above the respective threshold levels. The threshold level are assumed and not verified

C3.3.2 Discharge at the Gauging Stations

Likewise, average monthly discharge at the stations along Mekong in the study area was computed to derive annual discharge (Figure C3.3). Daily flood stage and re-charted rating curve for the respective stations were used. Since the original rating curves were not available at the time of study, they were re-charted by best fit curve based on the flood stage and discharge data available for 1965 (Figure C3.8 - 3.9). Due to inconsistency of data record, the period taken to obtain the mean value differs from station to station. However, care was taken to ensure some overlapping of period whenever possible.

Except for Neak Luong and Chaktomuk (Bassac), all other station along Mekong follow similar trend in increase and decrease of discharge. The delay in increase and decrease of discharge and the smaller magnitude at Neak Luong and Bassac river are the corollaries of the reverse flow in Tonle Sap river at the beginning and the emptying of Tonle Sap Lake at the end of rainy season. At Prek Kdam, the reverse flow occurs from June to September. If the amount of reverse flow is assumed to flow out again within a hydrological year, the ratio of reverse flow to catchment

flow is about 1:3.

The table below shows the maximum, minimum and the ratio between max and min discharge for the respective stations. The ratio is the highest (36.9) at Prek Kdam along Tonle Sap river, follows by Chaktomuk (29.9) at the confluence, the stations along Mekong (19.2-21.5) and Neak Luong (6.5).

Maximum, minimum and ratio of max and min discharge Unit: m^3/s

	Kratie	Kompong Cham	Chrouy Changvar	Neak Luong	Chaktomuk	Prek Kdam
Maximum	111.3	102.9	98.2	61.9	14.0	22.1
Minimum	5.8	4.8	5.0	9.5	0.5	0.6
Max/Min	19.2	21.5	19.6	6.5	29.9	36.9

Figure C3.10 shows the correlation of discharge between Kompong Cham and Chrouy Changvar and between Chrouy Changvar and Prek Kdam. The R^2 values are high, indicating good correlation between the stations. Discharge at Chrouy Changvar is less than that at Kompong Cham for discharge above 60000m^3/s, indicating that water flows out from the stretch of Mekong between Kompong Cham and Chrouy Changvar during high water.

Figure C3.11 shows the difference between water level at Chatomuk and Prek Kdam. Water level at Prek Kdam is higher than that at Chatomuk from February to September. From September to January, when flow in Tonle Sap river reverses, the reverse is true.

Figure C3.12 shows the fluctuation of water surface level in Mekong, Bassac and Tonle Sap rivers.

C3.4 Inundation Conditions

Topographically, except for the narrow strip along Mekong in Kratie province, the study area is below 30m elevation and makes up the eastern and lower part of the Mekong Delta in Cambodia. Area below 30m elevation, which covers 40% of total land area and in which 87% of the population inhabit, is referred to as the Mekong Delta in Cambodia (Mr. T. Kawai, 1996).

The table below shows the area inundated during rainy season. They were estimated from two sources: An existing study (DES AGRO-ECOSYSTEMES DE LA REPUBLIQUE POPULAIRE DU KAMPUCHEA, map 1:500,000, June 1986) showing average inundation condition (Figure C3.13, Depth and Duration of Inundation) and LANDSAT images of December 1994 procured for this study. The year 1994 was chosen because a) the images would show the recent rapid changes in land use in the study area. b) In 1994 the flood was severe and much of the study area was inundated. A check of rainfall shows that it was about the intensity of a 1/10 return period. c) The images of December 1994 obtained were the limited days with clear sky.

Area inundated during rainy season unit: ha

Duration	Negligible	Short	Average	Long		Total
AGRO-ECO	90,572	554,928	327,766	214,634	0	1,187,900
Depth	**0-0.3**	**0.3-1.0**	**1.0-1.5**	**1.5-3.0**	**>3.0**	**Total**
AGRO-ECO	311,887	171,199	252,004	297,676	155,134	1,187,900
LANDSAT	554,760	114,344	165,632	159,976	193,188	1,187,900

Note: AGRO-ECO data were measured from Carte Des Agro-ecosystems, LANDSAT was estimated from LANDSAT images Dec. 1994. Short (3-5), Average (5-6), Long > 7 months

The data of *LANDSAT* shows that the area not inundated (0-0.3m) is larger than that of *AGRO-ECO*, a trend as expected since much of the water would have receded by December of 1994. This is also true for area with inundation depth between 0.3-3.0m, 720,879ha of *AGRO-ECO* as compared with 439,952ha of *LANDSAT*. The area of inundation depth >3m for *LANDSAT* is slightly greater (25%) than that of *AGRO-ECO*. The *AGRO-ECO* data also show that about 74% of study area is subject to inundation during peak of flood period.

Figure C3.14 shows the change of flooded forest and water surface in the Study Area.

C3.5 Design Flood level and the Existing Levee

At present, flood intrusion by overtopping the banks is the overriding phenomena. While not advocating to completely keeping out annual flooding cycle in the flood plain, the relationship between flood level and embankment elevation can provide some useful cue on controlled flooding through colmatage and help to obviate undesired damages. Frequency analysis was performed for the gauging stations along Mekong, Tonle Sap and Bassac rivers to obtain the design flood levels. Figure C3.15 shows the longitudinal profile of the elevation of the right and left bank of the rivers and the design flood levels for 1/2, 1/10 and 1/100 return period. The plots shows that:

(A) Along the Bassac river, the right bank between Phnom Penh and Koh Khel is completely clear of the 1/2 and 1/10 level. The left bank is clear of the 1/2 level but is lower than the 1/10 level at 3 locations. Except for the right bank at Koh Khel, both banks are below the 1/100 level. The 1/2, 1/10 and 1/100 values downstream of Kho Khel were extrapolated and cannot be verified due to lack of information.

(B) Along the Tonle Sap river, the right bank is above the 1/2 and 1/10 level. Except for around Phnom Penh and Prek Kdam, the left bank is below 1/2 level for most of its length and is completely below 1/10 level. With the exception at 7 locations, the right bank is marginally above the 1/100 level.

(C) For the reaches between Phnom Penh and Neak Luong the right bank is above the 1/2 level while the left banks is below for quite a long stretch just downstream of Phnom Penh and at a few locations before Neak Luong. Except at 2 locations, the right bank is also above the 1/10 level and the left bank is below. Only at Neak Luong, both banks are marginally above the 1/100 level. The 1/2, 1/10 and 1/100 level after Neak Luong were extrapolated. Both banks are below the extrapolated 1/2, 1/10 and 1/100 values.

(D) For the reaches of Mekong between Chatomouk and Kompong Cham, the elevations of both banks are marginally higher than the 1/2 level, with the exception at few locations. Only the right banks at around Phnom Penh and Kompong Cham are above the 1/10 level. The banks in between the cities are all below the 1/10 and 1/100 level.

Figure C3.16 shows the stretches of banks along Mekong, Bassac and Tonle Sap rivers that are below the water level of 1/2 (a), 1/10 (b) and 1/100 (c) return period. It is evident that quite some stretches along the left bank of Mekong and Tonle Sap river are below the 1/2 R.P. level (a). Some locations of NR No.1 between Phnom Penh and Neak Luong are below the 1/10 R.P. level and need to be raised (b). Most of the length of the roads along Mekong, Bassac and Tonle Sap river are below the 1/100 R.P. level (c).

C3.6 Water Balance of the Mekong River

Daily discharge data at the gauging stations were summated over several years to obtain mean annual discharge at the respective stations. The value for Kratie obtained in this study (Figure C3.17) is about 1.09 times larger than published data. Annual discharge at Kratie is estimated at 482.2km^3, Kompong Cham 431.4km^3, Chrouy Changvar 416.8km^3, Neak Luong 358.9km^3, Chaktomuk (Bassac) 58.6km^3 and Prek Kdam 25.6km^3.

Published data: *Only about 10% of the discharge of Mekong comes from the catchment in Cambodia (about 23% of catchment of Mekong): average annual flow at Kratie, 441km^3, is estimated at about 93% of the total Mekong runoff discharge (475km^3) into the sea (Cambodia, Business & Investment Handbook, 1996).*

Water balance for each of the intervals between the gauging stations along Mekong in the study area was calculated, based on average annual discharge, mainly to evaluate the outflow from Mekong river into the colmatage canals and preks and the return flow from the canals and preks into Mekong (Figure C3.17). For example, for the reach between Kratie and Kompong Cham, about 51,400MCM flow out of Mekong as compared to 600MCM flowing in annually. It is also clear that for the Middle Tonle Thom (Mekong between Kratie and Phnom Penh) more water flows out from Mekong between the reach Kratie to Kompong Cham than that between the reach Kompong Cham to Phnom Penh. Within the later reach, the over-bank flow on the right bank of Mekong flows toward Tonle Sap Lake, in addition of the reverse flow through Tonle Sap river at Phnom Penh.

At Prek Kdam the annual flow, reverse flow and catchment flow are estimated at 71,400MCM, 45,700MCM and 25,600MCM, respectively. About 11% of Mekong water flows into Tonle Sap Lake annually (20% is one of the published values). This water balance estimated for Tonle Sap Lake at Prek Kdam agreed reasonably well with the values re-evaluated by the expert attached to DOIMH. The normal flow (outflow) at Prek Kdam had been estimated at 72,900MCM, reverse flow at Prek Kdam at 45,000MCM and inflow from river catchment at 24,300MCM. Carbonnel & Guiscafre estimated reverse flow and catchment flow for 1962-63 at Prek Kdam at 45,000MCM and 27,900MCM, respectively.

Figure C3.18 shows overtopping and flow into/out from colmatage and tributaries.

C3.7 Other Hydrological Data

Figure C3.19 - C3.22 were extracted from "Irrigation Rehabilitation Study in Cambodia". Figure C3.19 shows the discharge at Kratie, Kompong Cham, Phnom Penh and Neak Lung along Mekong river. Figure C3.20 shows the schematic river network in Cambodia. Figure C3.21 shows the relation of maximum flood and catchment area, and variation of water surface level along Mekong river. Figure C3.22 shows the frequency of peak water level.

C3.8 The Role of Flood Plain and Tonle Sap Lake

Annual flooding cycle is life blood of Cambodia. It usually begins in August and the floodwater starts to ebb in Oct-Nov. About 2/3 of the agricultural land in the flood plain is flooded during crest water level each year. It is alleged that the nutrient-rich silt-laden floodwater of Mekong and its tributaries is important to rice production. The life cycle of the fishes in the lower Mekong is also dependent on the annual cycle of flooding (it is in the trait of fish to migrate against the current). The flooded forest in the flood plain and reserve forest on the peripheral of Tonle Sap Lake are repeatedly inundated yearly and are vital spawning and breeding ground for fishes.

The lake surface during reverse flow of Tonle Sap river (mid June to early October) increases by about 3.8 times, to about 1 million ha (10,000km^2) from 260,000 ha (2,600km^2), raising lake level by an average of 7m during the peak of flooding, and thus acting as a natural retention basin. The total area flooded is about 10.5% of total land area, not including the inundated area along Mekong and Tonle Sap rivers outside the study area and Svay Rieng province: Tonle Sap Lake is about 10,000km^2 or 5.6% and the flood plain in the study area is about 8,953 km^2 or 4.9% of total land area (181,035km^2). This is large when compare with land under agriculture in Cambodia which is about 20% of total land area.

The flood plain, including the Tonle Sap Lake, is crucial to the well-being of not Cambodia but also Viet Nam as well. It acts as a buffer or flood regulator of the lower Mekong basin, drawing off water during peak of the flood and adding it back later in the year. It also serves to limit salinity intrusion in the lower delta area in Viet Nam and the waters draining from the plain, especially the Lake, are rich in nitrogenous products that provide food for the masses of marine life that aggregate every year off the coast of Viet Nam to feed in the plumes of the Mekong and Bassac rivers (Cambodia, An environmental and Agricultural Overview and Sustainable Development Strategy, Michael D. Benge, USAID, 1991).

The effect of Tonle Sap Lake, as a buffer of peak flow and supply of water during dry months, is evident

from the distinct change in the shape of monthly flow curve of Mekong river before and after Phnom Penh. The average monthly flow curve at Stung Treng, Kompong Cham and Phnom Penh at Chroay Changvar (just before Mekong and Tonle Sap River confluence) follow similar trend, with water level start to rise in June, peak in September and level off in January. The flow curve at Neak Luong shows a different trend: the rising trend starts in July, a month late, and is similar to those further upstream but smaller in magnitude. The ebbing trend is also of smaller magnitude. The distinct difference is the flow in the month from January to June where the flow stays relatively constant and is larger than those in the upstream (Irrigation Rehabilitation Study in Cambodia, HALCROW 1994, Mekong Committee).

This general trend is confirmed in this study. The discharge curve at Neak Luong shows that ebbing in September is small. Water starts to ebb more swiftly from October and the trend, on the whole is smaller in magnitude due to the outflow from the Tonle Sap Lake. Similar trend is observed for Bassac river at Chaktomuk (Figure C3.3). Velocity of Tonle Sap river during reverse flow is 1.8m/s while the following normal flow is about 2m/s.

C3.9 Potentials and constraints

C3.9.1 Rainfall

Rainfall in the study area comes mainly from the southwest monsoon (May to October). This means that the remaining half of the year has very little rain for irrigation. Rainfall very often occurs in high intensity. See below for the difference in occurrence between rainy and dry season, average annual rainy days and rainfall intensity for days with rainfall greater than 5mm/day.

Rainfall occurrence, average rainy day and rainfall intensity

Unit: %,day ,mm/day

	Kratie	Kompong Cham	Phnom Penh	Prey Veng	Takeo
May-Oct	11	15	15	17	15
Dec-Apr	89	85	85	83	85
Rainy day	66.5	62.9	56.5	50.8	51.6
Intensity	23.3	22.6	22.7	22.9	27.2

Total annual rainfall is less than evaporation and the deficiency will have to be supplemented by irrigation with floodwater stored in the flood plain: In rainy season ETo < rainfall but in dry season ETo > rainfall. Effective rainfall (summation of 80% of daily rainfall between

5mm and 80mm) is even much less, about 53-55% of annual total rainfall. Due to uneven rainfall distribution varying from place to place and from year to year, almost all localities suffer from drought differing in intensity and duration. Also, the delay of rainfall and short period of dry spell in the early rainy season often result in delay in cultivation. The deficiency, uncertainty, delay of rainfall and short dry spell, together making rainfall one of the major constraints, corroborate the need to develop reliable water resources for irrigation.

C3.9.2 Flooding

Flooding is a part of flow of life and is believed to be the source of fertility in Cambodia. Most of the riparian inhabitants consider flood to be helpful as long as it is not too deep and/or it does not stay too long. Efforts to contain the flood, which is unwise, will entail comprehensive study on impacts on the fragile eco-system of Mekong delta.

It is difficult to tame the dynamic flow of Mekong River. It swells to about 20 times (20x) during the rainy season: at Kratie 19x, Kompong Cham 22x, Chrouy Changvar 19x, Chaktomuk 14x, Neak Luong 7x, Prek Kdam 37x for normal flow and 7x for reverse flow. At some locations the water overtops the banks, especially between Kratie and Phnom Penh.

Flooding indeed limits land availability for agriculture when water is in abundant supply. Adapting the type of crops and cultivation practice to flooding are some of the means to increase the potential and active use of floodwater. About 214,634 ha remains flooded for a period of over 7 months and can be considered as "permanent wetland". This wetland has great potentials for water resource and fishery development, by developing a more extensive canal network and storage facilities like those further downstream in the Mekong delta complex in Viet Nam. With proper operation and management of these facilities this can help to further delay the ebbing of floodwater stored during wet season and could be very beneficial to the study area and the delta further downstream.

It is clear that most of the inundated low-lying areas in the study area is a continuation of the back swamps of Mekong delta when it is viewed together with the inundation conditions in Viet Nam. Only the upper part of the delta in Viet Nam is subject to inundation of over 1m and the area inundated for over 5 months is relatively small. Comparison of the inundation conditions in the study area reveals that inundation depth is somewhat less severe and the area inundated for a period greater than 5 months is relatively less in the delta in Viet Nam.

C3.9.3 Clogging and siltation in colmatage canal

The sediment, clay and silt riding on the in-flowing water, is deposited along a distance of about 500-2,000m from the inlet of colmatage canals and preks, as evident from the color of inundated water surface. Flow velocity is about 1.0-1.5m/s at the inlet and is retarded after a distance of 1-3km. The farmers dredge the small lateral canals fed by the colmatage canal at the beginning of season each year, heaping the sand and silt on the fields along the lateral canals. Dredging and sluicing of the colmatage canals required a more organized and consorted efforts. Not much has been done to maintain the function of colmatage canals so far and quite a few are completely clogged, admitting water only when the water level in the rivers becomes much higher later in the season.

C3.10 Mekong Flood and Siltation for Agriculture

C3.10.1 Existing Studies

The Harza Engineering Company conducted suspended sampling along the Mekong in 1960 & 1961. A plot of the sediment concentration and discharge as a function of time, reproduced by Uehara from the summary report complied by the Naval Oceanographic Office, is shown in Figure C3.23. Since water picks up more loose materials at the beginning of the monsoon, the sediment concentration peaks in August, about 1-2 months before discharge peak.

The readily soluble nutrient added to a one hectare area as measured by mild acid extraction amounted to 1.0 kg P, 3.2 kg K, 4 kg Mg and 50 kg Ca per hectare. It was concluded that even if these computed values were doubled, the sediment deposit could not significantly increase the fertility of Delta soils (The composition of Mekong River Silt and its possible role as a source of plant nutrient in delta soil, Goro Uehara, et la, University if Hawaii, 1974). In the report it was also mentioned that there is a small but significant difference in mineral, chemical, and acid extractable nutrient content between sediment and soil.

The average sediment concentration is about 1,000 ppm just west of Vientiane and ranks 13th among the largest sediment carrying rivers in the world. This concentration is double that of Mississippi, 1/3 that of Rio Grande and Missouri and 1/10 that of Colorado (Pa Mong Phase II, 1972).

C3.10.2 Suspended Solid Survey conducted in this Study

In this study, water quality survey and sampling were conducted for two times only, once each for the dry and wet season, aiming to capture the anticipated concentration difference in suspended solids between dry and wet season. See Figure C4.1 for sampling sites and Table C4.2 for the results for wet season. The results are therefore insufficient to elucidate the change of annual sediment concentration.

Surface river water at the middle of Mekong (at R1 Kompong Cham, R2 Neak Luong and R3 Prek Dach) and Tonle Sap river (at R4 Prek Kdam) was sampled from ferry boat. For other locations water was sampled near the bank as no boat was available. The result will therefore shows the total suspended solid and does not represent bed/sediment load. The suspended solid is assumed to be evenly distributed throughout the river section considering the current and whirlpools of the flow in the rainy season.

Except for Prek Kdam, the sample results show that total suspended solids in the flow of Mekong river during rainy season ranges from about 1376 mg/l at Kompong Cham to 516mg/l at Neak Luong (Table C4.2). The low value at Prek Kdam, 84mg/l, suggests that silting of Tonle Sap Lake can be attributed mainly to the sediment from breaking up new pieces of forest for cultivation and logging in its catchment, rather than to the sediment from the reverse flow from Mekong river. Carbonnel, in his work "Report of the French Sedimentation Mission, 1964", expressed that "the materials brought by the Mekong in high water periods is negligible in the Great Lake proper and consequently does in no way modify the accumulation rate in the Great lake."

C3.11 Water Resources for Agriculture Development

Except for Neak Loung, the percentage of discharge for the 1st half of the year (Jan-Jun) to the 2nd half (Jul-Dec) for the stations along Mekong is 15%-85% (see below). Only 15% of annual total is available in dry season when water is needed most.

Average flow for the 1st and 2nd half of a year

Unit: %

	Kratie	Kompong Cham	Chrouy Changvar	Chatomuk	Neak Luong	Prek Kdam
First half	15	14	14	9	23	36
Second half	85	86	86	91	77	64

Note: 1st half: January to June, 2nd half: July to December

For Prek Kdam the values show the percentage of catchment and reverse flow

From the results of water balance of the gauging stations (Figure C3.17), it is seen that about 11% (51,400MCM) of the annual discharge at Kratie flows into the tributaries and colmatage canals or overtopping the banks between Kratie and Kompong Cham. Between Kompong Cham and Chrouy Changvar 4% (17,600MCM) and between Chrouy Changvar and Neak Luong 10% (42,700MCM).

These waters are stored in the huge inundated areas of varying depths and duration during the rainy season. The "permanent wetland" (inundation depth > 3m, lasting from August to March/April) is about 214,600ha, or 18% of the study area. The total volume of floodwater stored in the permanent wetland is estimated at 6,400MCM (70% with 3m and 30% with 2.5m depth), or 2.85MCM/km^2. For Tonle Sap Lake the value is 4.5MCM/km^2 (72,000MCM in 16,000km^2, Development Plan for Tonle Sap Lake and Chakdomuk, Mekong Secretariat, by ORSTOM & BCEOM, Oct. 1993)

Since there is no gauging station further downstream, water balance after Neak Luong and Bassac river was estimated by annual flow into the preks and colmatage canals. The total amount of water channeled into the fields and backswamps by the colmatage canals (285 with average section 26m^2 and flow velocity of 1m/s) along Bassac river and along Mekong river after Neak Luong from August to October is estimated at 59,000MCM. With improvement by dredging and lowering the bed of colmatage canals and preks by 2m, about twice the volume can be expected.

With this water about 12,000,000 ton or 5mm of sediment is deposited along the colmatage canals and the backswamps (SS 200mg/l, specific gravity 1.3t/m^3 on an area of 177,584 ha). The estimated value, 12,000,000ton of sediment, is about 5% of the average transport rate at Kratie (averaging at 250,000,000t/year for 1986-1990, "The Lower Mekong Basin - Suspended sediment transport and sedimentation problems", P.O. Harden & A. Sundborg, 1992).

The above estimations show that about 170,700MCM, or 35.4% of average annual Mekong discharge at Kratie, overflows the banks of Mekong, Bassac and Tone Sap rivers into the study area during the rainy season. Most of the floodwater flows back into the main streams or flow directly downstream to the Mekong delta complex in Viet Nam via the main tributaries such as Tonle Toch and Stung Takeo. The amount of floodwater stored in the permanent wetlands in the study area is estimated at 6,400MCM, or about 1.3% of average annual Mekong flow at Kratie. They all imply that storing floodwater in the flood plain for dry season irrigation still has a great development potential.