UNITED NATIONS ENVIRONMENT PROGRAMME

EAST ASIAN SEAS REGIONAL COORDINATING UNIT

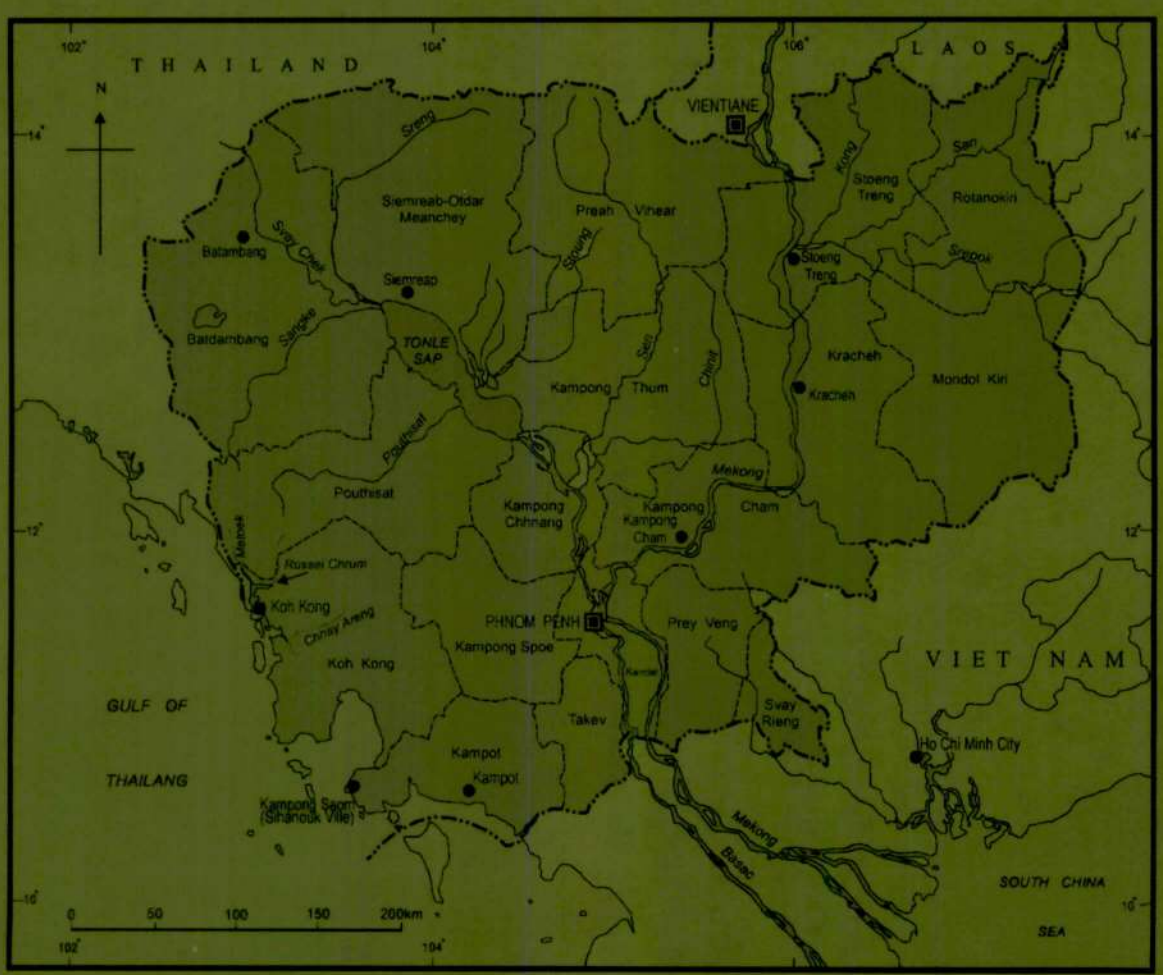
UNEP

UNEP/GEF
Project Coordinating Unit

NATIONAL REPORT OF CAMBODIA

on the

Formulation of a Transboundary Diagnostic Analysis and Preliminary Framework of a Strategic Action Programme for the South China Sea



UNITED NATIONS ENVIRONMENT PROGRAMME

EAST ASIAN SEAS REGIONAL COORDINATING UNIT

NATIONAL REPORT OF CAMBODIA

on the

Formulation of a Transboundary Diagnostic Analysis and Preliminary Framework of a Strategic Action Programme for the South China Sea

TABLE OF CONTENTS

ANNEXES

LIST OF TABLES

LIST OF FIGURES

NATIONAL STUDY TEAM

I. Ministry of Environment

1. **National Coordinator**
   Mr Long Rithirak

2. **Department of Environmental Pollution Control**
   Mr Chea Sina
   Mr Son Dara
   Mr Chap Youthy
   Ms Phoung Sothy

3. **Department of Natural Conservation and Protection**
   Mr Pich Sam Ang
   Mr Kay Pheng
   Mr Pich Sameth

4. **Department of Natural Resources Assessment and Environmental Data Management/GIS**
   Mr Moa Socheat
   Mr Lim Sovannra

5. **Technical Coordination Unit for Tonle Sap**
   Dr Neou Bonheur

II. Ministry of Agriculture Fishery and Forestry

General Directorate of Irrigation, Meteorology and Hydrology
Ms Koung Vutheary

III. Ministry of Industry Mines and Energy

Department of Planning
Mr Puth Keath

IV. Ministry of Planning
Dr Souv Sisovanna

V. National Mekong Secretariat
Mr Chin Samuth
Mr Chrin Sokha

1. INTRODUCTION

1.1 AIM OF THE NATIONAL REPORT

This report is the collective work of different national institutions. It seeks to analyse water-related problems in terms of environmental issues that accrue from pollution, freshwater shortage, and sedimentation from deforestation in catchment areas of Tonle Sap Great Lake and the Mekong river, over exploitation of aquatic resources, and habitat modification. The purpose of this National Report is to provide background data, information and understanding on the environmental problems and issues for the Regional Transboundary Diagnostic Analysis organized by the United Nation Environmental Programme (UNEP). This effort is an inter agency initiative of the national government organizations under the coordination of the Ministry of Environment (MoE).

The inputs of the report have been prepared to meet the requirements of contract NO. CON/85/45 of the 2 July 1998 between ESCAP/UNEP and the Ministry of Environment.

1.2 MAJOR WATER-RELATED ENVIRONMENT PROBLEMS

Freshwater

- Contamination in water quality due to domestic and non-point source pollution, from sedimentation.
- Over fishing, decline in fishstock.
- Deforestation of flooded forests, used as breeding grounds and nurseries.
- Flooding, urban areas along the Mekong River and Phnom Penh city.

Marine and Coastal areas

- Degradation in water quality due to domestic and non-point source pollution.
- Over fishing, and destruction of fishstock by using dynamite.
- Reclamation of mangrove into shrimp culture ponds.
- High demand for mangrove charcoal production.
- Destruction of coral reef and seagrass beds.
- Erosion caused by deforestation.

1.3 COUNTRY BACKGROUND

Cambodia is a country covering an area of 181,535 km^2. It is situated in South-East Asia, forming part of the southwestern portion of the Indochinese peninsula between latitudes 10° and 15° north and longitudes 102° and 108° east. The country's maximum extent is about 580 km from east to west and 450 km from north to south. Cambodia shares its 2,438 km border with Thailand (in the west and north), Laos (in the north) and Viet Nam (in the east and southeast). In the southwest Cambodia is bordered by the Gulf of Thailand. Cambodia has a 435km coastline on the Gulf of Thailand, three provinces occupy this coastline: Koh Kong, Sihanouk Ville, and Kompot. The Cambodian coastal zone is located in the southwest part of the country, and the coastal watershed lying outside the Tonle Sap Lake, comprises an area of approximately 18,300 sq. Km.

There has been no population census since 1962, and the profound but imprecisely recorded changes in population trends that have occurred as a result of war, internal displacement and international migration, render population estimates subject to a significant degree of error. This imprecision has potentially serious implications for national development and strategic planning,

although a population survey was planned for 1996 and a census for 1998. However, while current population estimates tend to differ, the population is officially estimated to have been some 10.2 million in 1995 and to be increasing at about 2.8 percent a year, implying a total population of around 11.7 million by the year 2000. Approximately 47 percent of the population is under five years of age, indicating a high dependency ratio, and some 53 percent of the population is female, rising to 58 percent among those groups over forty years of age.

Cambodia's population is unevenly distributed, with relatively high densities in the provinces of the central plains and low densities in the provinces of the surrounding highlands. Thus, Phnom Penh and seven provinces (Kompong Cham, Prey Veng, Kandal, Takeo, Battambang, Siem Reap and Kompong Thom) contain some 69 per cent of the national population and 36 per cent of the total land area; Sihanouk Ville and a further seven provinces (Kampot, Kompong Speu, Svay Rieng, Banteay Meanchey, Kompong Chhang, Pursat and Kratie) contain 28 per cent of the population and 30 per cent of the land area; while five provinces (Preah Vihear, Rattanakiri, Stung Treng, Koh Kong and Mondolkiri) contain 3 per cent of the population and 34 per cent of the land area.

1.4 GEOGRAPHIC DIVISIONS USED IN THE ANALYSIS

Geographic divisions used in the analysis are as follows:

(a) The catchment area of the Mekong River system;
(b) The catchment area of the Tonle Sap River system;
(c) The catchment area of the coastline.

The Mekong River, 4,200 kilometres in length, is the longest in South-East Asia and the twelfth longest river in the world. Starting from the snow melts of the Himalayan Mountains in China it passes through Myanmar, the Lao People's Democratic Republic, Thailand, Cambodia and Viet Nam before discharging into the South China Sea. In Cambodia, the river runs for 486 kilometres. It enters Cambodia from the Lao People's Democratic Republic in the north-east and flows southward until it is deflected westward by the basalt of the terre rouge area (red land hills). It passes through this basalt before continuing south-westward to Phnom Penh where it divides into two main downriver branches, the Bassac River and Mekong River. Both rivers form the wide Mekong delta starting in south-east Cambodia and enlarging further in Viet Nam.

The Tonle Sap Basin includes the Tonle Sap Great Lake, which is the largest permanent freshwater lake in South-East Asia. The Tonle Sap Lake is connected to the Mekong River at Phnom Penh by the 120 kilometres long channel-like Tonle Sap River. The confluence of Mekong Bassac and Tonle Sap River is called Chaktomuk Quatre Bras.

The central plain is surrounded by savanna and gradually changes into more densely forested and sparsely populated highlands and mountains. The exception is in the south-east, where these plains run all the way to the Vietnamese border enclosing the downriver branches of the Mekong River.

The coastal zone of Cambodia is unique to the rest of the country and requires special attention. Currently, the coastal watershed boasts approximately 10 per cent of the total population. However, second to the capital city Phnom Penh, it has the highest growth rate largely because of immigration. Because of the natural resource base and beaches, the area is considered a prime area for foreign and domestic tourism investments.

However, non-sustainable use of natural resources and mismanagement of wastes are damaging the environment in the coastal area. Previously pristine mangrove forests are now degraded and the fish catch is reported to be decreasing. The causes for the degradation of the environment are multifaceted and stem from both human and naturally occurring activities. At the present time, there are no management guidelines that account for the integrated nature of these activities. In addition, as the population increases, so do pressures on the environment. The current rapid development without an integrative approach may destroy the environment and as a consequence the economic development and well-being of the people. Development should take into account the inter-dependence of different sectors. Development has to be viewed within the context of the overall system including production, distribution, and consumption subsystems, which in turn are influenced by the performance of other sectors as well as the socio-cultural and political systems. A plan recognizing the needs and priorities for the development of the country while considering the environment should help minimize adverse environmental effects and provide for a growth strategy that will enable future generations to have a higher standard of living.

2. DETAILED ANALYSIS OF THE MAJOR WATER-RELATED CONCERNS AND PRINCIPAL ISSUES

2.1 POLLUTION

2.1.1 Sources of pollution

2.1.1.1 Rivers

Cambodia is a country covering an area of 181,535 square kilometres. According to the topography of the country, the rivers in Cambodia are divided into three systems (figure 2.1):

(a) The Mekong River system, located in the eastern catchment of the central plains of the country;
(b) The Tonle Sap River system, located in the central plains of the country;
(c) The coastal river system, located in the south-west of the country, along the country 's coastal zone of the Gulf of Thailand.

- ***The Mekong River system***

The biggest river in the system is the Mekong River, which enters Cambodia from the Lao People's Democratic Republic in the north-east and flows southward to Phnom Penh where it divides into two main downstream river branches, the Bassac River and the Mekong River. Both rivers form the wide Mekong delta starting in south-eastern Cambodia and enlarging further in Viet Nam.

In the Mekong River system, there are 10 tributaries of the Mekong River that have a catchment area of more than 1,000 square kilometres (table 2.1). The total basin of the river system is about 70,060 square kilometres, about 39 per cent of the country.

Table 2.1 The main characteristics of the 10 big rivers in the Mekong River system

N°	Name of river	Catchment area (km^2)	Rainfall high (mm)	Rainfall volume ($x10^6 .m^3$)	Annual average discharge (m^3/s)	Annual discharged water volume ($x10^6 .m^3$)
1	Mekong	23,736	1,499	35,580.26	458	14,455.22
2	Se Kong	5,514	2,203	12,147.34	1,221	38,480.00
3	Se San	7,773	2,023	15,724.78	641	20,214.00
4	Sre Pok	12,762	2,129	27,170.30	1,177	37,134.72
5	Prek Preah	1,499	1,952	2,926.05	50	1,579.94
6	Prek Krieng	2,392	1,879	4,494.57	74	2,348.94
7	Prek Kompi	1,133	1,674	1,896.64	28	884.87
8	Prek Te	4,303	1,822	7,840.06	126	3,984.58
9	Prek Chhlong	5,689	1,763	10,029.70	157	4,938.05
10	Prek Thnot	5,606	1,586	8,891.11	114	3,585.20
11	Stung Slakou	1,653	1,540	2,545.62	25	778.80

Sources: Irrigation Rehabilitation Study in Cambodia, June 1994;
Mekong Secretariat, 1993.

- ***The Tonle Sap River system***

The Tonle Sap River basin includes the Tonle Sap Great Lake which is the largest permanent freshwater lake in South-East Asia. The Tonle Sap Lake is connected to the Mekong River at Phnom Penh by the 100 kilometre channel-like Tonle Sap River.

The flow of the Tonle Sap River reverses during the rainy season (from June to October), bringing the Mekong water to the Great Lake which acts as a natural reservoir for the flooding river. During the dry season (from November to June), the Tonle Sap River is the only outlet for the Great Lake which empties gradually into the Mekong River.

In the Tonle Sap River system, the Great Lake covers an area of 10,500 square kilometres (FAO 1994) or nearly 6 per cent of the total area of the country. Sixteen tributaries of the Great Lake and the Tonle Sap River have a catchment area of more than 800 square kilometres (table 2.2). The total drainage basin of the Tonle Sap River system is about 67,600 square kilometres (Mekong Secretariat 1993), about 37 per cent of the country.

Table 2.2 The main characteristics of the rivers in the Tonle Sap River system

N°	Name of river	Catchment area (km^2)	Rainfall high (mm)	Rainfall volume ($x10^6 .m^3$)	Annual average discharge (m^3/s)	Annual discharged water volume ($x10^6.m^3$)
1	Tonle Sap & Lake	17,412	1,464	25,491.16	317	10,011.90
2	Stung Boribo	827	1,691	1,398.45	21	659.95
3	Stung Chinit	4,504	1,358	6,116.43	67	2,121.38
4	Stung Taingkrasin	1,145	1,358	1,554.91	17	538.15
5	Stung Sen	13,653	1,131	15,441.54	107	3,385.95
6	Stung Pursat	4,505	1,684	7,586.42	113	3,558.95
7	Stung Dountri	819	1,376	1,126.94	13	400.49
8	Stung Sangker	3,225	1,565	5,047.12	69	2,173.65
9	Stung Mongkol Borey	3,156	1,612	7,163.72	101	3,199.68
10	Stung Sisophon	2,388	1,484	6,445.01	82	2,579.74
11	Stung Svay Chak	1,249	1,304	2,743.61	28	879.47
12	Stung Praneth Preah	1,387	1,395	1,934.86	22	703.21
13	Stung Sreng	9,471	1,369	12,965.80	145	4,565.02
14	Stung Siem Reap	842	1,403	1,181.32	14	433.63
15	Stung Roluos	889	1,324	1,177.32	`12	389.33
16	Stung Chikreng	1,871	1,146	1,144.16	16	492.07
17	Stung Stoung	2,012	1,058	2,128.69	11	354.11

Sources: Irrigation Rehabilitation Study in Cambodia, June 1994; Mekong Secretariat, 1993.

- ***The coastal river system***

Along the country's coastal line of 435 kilometres on the Gulf of Thailand, the rivers drain westwards from the Cardamon Mountains, and have relatively limited catchments (approximately 15 per cent of Cambodia's land area), their flows reflecting the local and higher rainfall pattern. Highly coordinated drainage systems characterize the southerly fall of the coastal ranges except on the lowland around the Bay of Sihanouk Ville which generally features smaller and simpler drainage systems.

The rivers that flow into the Gulf of Thailand are relatively small with water levels increasing and decreasing significantly with the volume of rainfall. The rivers in the coastal area are generally short and have their sources in hills of about 500 to 600 metres altitude. They meander between hills and fall in cascades before reaching the plain located 15 to 20 kilometres from the sea. In the delta areas, the rivers divide into many estuaries where the level of turbidity is usually high and where there are several marsh areas covered by mangrove forests.

There are many streams located in the coastal area which usually dry up in the dry season. Most of the rivers in the coastal zone are also influenced by the sea. In the dry season, the low-lying rivers are filled with seawater.

In the coastal river system there are only seven big rivers with a catchment area of more than 1,000 square kilometres (table 2.3). They are from north to south: Stung Metoek, Stung Russei Chrum, Stung Sala Munthun, Stung Chhay Areng, Prek Piphot, Prek Kompong Som and Prek Toeuk Chhou.

Apart from these rivers, there are several small streams that in the rainy season carry organic and other materials into the sea.

Table 2.3 The main characteristics of the seven big rivers in the coastal river system

N°	Name of river	Catchment area (km^2)	Rainfall high (mm)	Rainfall volume ($x10^6.m^3$)	Annual average discharge (m^3/s)	Annual discharged water volume ($x10^6.m^3$)
1	Stung Metoek	1,135	3,305	3,751.17	86	2,703.57
2	Stung Russei Chrum	2,726	2,665	7,264.79	152	4,781.40
3	Stung Sala Munthun	1,568	2,783	4,363.74	93	2,932.16
4	Stung Chhay Areng	2,107	2,873	6,053.41	131	4,127.61
5	Prek Piphot	1,164	3,032	3,529.25	78	1,354.90
6	Prek Kompong Som	2,645	2,214	5,856.03	110	3,467.59
7	Prek Toeuk Chhou	2,061	2,077	4,280.69	77	2,425.80

Sources: Irrigation Rehabilitation Study in Cambodia, June 1994;
Coastal Zone Management in Cambodia, February 1996.

2.1.1.2 Coastal cities and coastal population

The Cambodian coastal zone is located in the south-west of the country between 8 and 12 degrees north of the equator. The coastal watershed comprises an area of approximately 18,300 square kilometres and consists primarily of three provinces: Koh Kong, Sihanouk Ville, and Kampot (figure 2.2). The total length of the Cambodian coastline is approximately 435 kilometres.

In 1997, the total population in the three coastal provinces was estimated to be 7.3 per cent (840,000 people) of the total Cambodian population of about 11.5 million (Ministry of Planning 1997). Similar to the country as a whole, the majority of the people in the coastal provinces of Cambodia live in the rural areas. In 1995 the following estimates of people living in rural areas of the coastal provinces were made by the Mekong Secretariat, as shown in the table 2.4 .

Table 2.4 Estimates of population living in the rural areas of the coastal provinces

Coastal provinces	**Estimated population**	**Estimated population living**			
	in 1997 (persons)	**in rural areas**		**in urban areas**	
		Percentage	Persons	Percentage	Persons
Koh Kong	105,000	77 per cent	80, 850	23 per cent	24,150
Sihanoukville	132,000	58 per cent	76,560	42 per cent	55,440
Kampot	603,000	95 per cent	572,850	5 per cent	30,150
	Total 840.000	**Average 77 per cent**	**Total 730,260**	**Average 23 per cent**	**Total 109,740**

Sources: Coastal Zone Management in Cambodia, February 1996;
Mekong Secretariat, 1995.

The population densities of the coastal provinces vary from 9 to 152 persons per square kilometre. The coastal provinces, except Koh Kong, are the most densely populated areas in the country, and Sihanouk Ville is the most densely populated province in the coastal area, as shown in table 2.5.

Table 2.5 Population density in the coastal area

Coastal provinces	**Area** (km^2)	**Estimated coastline length** (km)	**Estimated population in 1997**	**Population density** (people / km^2)
Koh Kong	11,160	260	105,000	9
Sihanouk Ville	868	100	132,000	152
Kampot	5,209	75	603,000	115
Total	**17,237**	**435**	**840,000**	**average 92**

Sources: Provincial Office of Planning Report, Koh Kong, Sihanoukville, and Kampot, 1995;
Ministry of Planning, 1997.

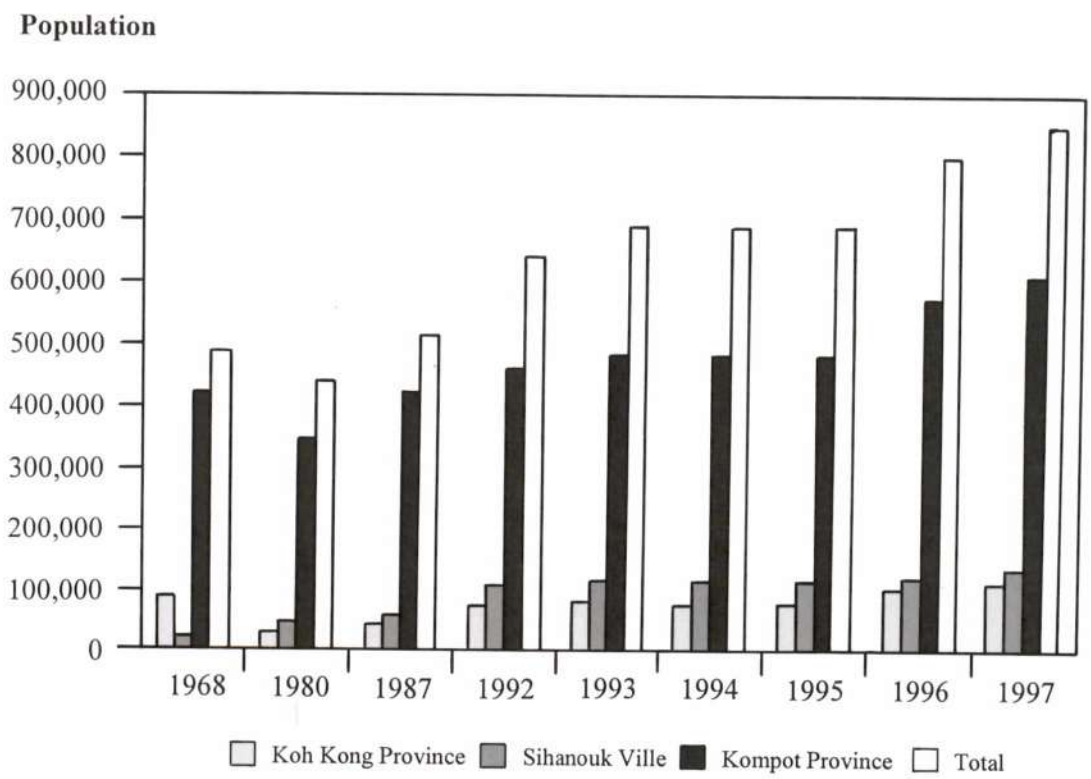
Population growth in the Cambodian coastal provinces has been increasing steadily since the war, as shown in table 2.6 and figure 2.3.

Table 2.6 Population growth estimates in the coastal provinces, 1968 - 1997

Coastal provinces	Population (1,000 persons)								
	1968	**1980**	**1987**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Koh Kong	95	25	30	70	74	71	79	102	105
Sihanouk Ville	15	51	61	107	114	121	120	128	132
Kampot	414	348	412	454	482	481	476	559	603
TOTAL	**474**	**424**	**503**	**631**	**670**	**673**	**675**	**789**	**840**

Sources: 1968, 1980 and 1987 data extracted from the Economic and Demographic Statistical Assessment Mission to Cambodia, UNDP, March 1991;
1992, 1993 and 1994 data from the Ministry of Planning Department of Statistics, 1994;
1995 data from provincial offices of planning, 1995;
1996 data from the National Institute of Research, 1996;
1997 data from the Ministry of Planning, 1997.

Figure 2.3 Population growth in the coastal area (from 1968 to 1997)



2.1.1.3 Industrial pollution from coastal installations

In Cambodia, industrial development in the coastal area is on a small scale. According to data from the Ministry of Industry, Mines and Energy, there are some factories and handicrafts such as: garments and shoes, seafood processing, animal feed, ice factories, fish souse, sawmills, beer brewery, plywood, oil and gas storage facilities, silica factory, cement plant, salt industry, phosphate fertilizer factory, power plant, and *voa romeat* (khmer language) factory. *Voa romeat* is reportedly a medicinal herb and a potentially harmful waste is produced during the manufacturing of the medicine. At present, there are 32 factories operating in Sihanouk Ville, 106 factories in Kampot, and 6 factories in Koh Kong (see table 2.10).

In order to improve the country's economy the Government plans to develop the industrial sector in some areas of the country, particularly in Sihanouk Ville. To achieve this goal the Government has set up a policy to encourage investment in agro-industrial enterprises and the production of fertilizer, petroleum, heavy construction and mechanical equipment. The Government has announced plans to establish an industrial zone with an area of 900 hectares and an export processing zone with an area of 260 hectares in Sihanouk Ville.

Most of the wastewater of all factories and handicrafts on the coast has been discharged directly or indirectly into nearby waterways and then to the sea without any treatment. The data on quality and quantity of the wastewater discharged from the factories located in the coastal zone are not available because there has not been any survey on this matter yet.

Oil and gas: Recent results from offshore and onshore exploratory drilling suggest that Cambodia has a high potential for natural gas and a modest potential for oil. Several areas in the coastal zone have been explored in the past and continue to be explored for oil and gas supplies. Currently, there are no production wells, only exploration activities. The zones of oil and gas exploration in the coastal area are presented in figure 2.4.

The Government has already entered into contracts permitting companies to conduct offshore exploration for gas and oil. The contracts contain a clause prohibiting waste disposal into the sea. These companies have demanded that the Government provide environmental inspectors to evaluate and control environmental problems.

Cambodia's claimed production block and exploration results are briefly summarized below:

- ***Offshore Blocks:***

1 . **Block I** (approximately 4,700 km^2)
   - Awarded in October 1991 to Enterprise Oil Exploration Ltd. And Company Europe Des Petrols
   - Seismic studies conducted in 1992
   - Total and British Gas joined in May 1993

2 . **Block II** (approximately 4,900 km^2)
   - Awarded in October 1991 to Enterprise Oil jointly with Block I
   - Geophysical surveys conducted in 1992
   - Total and British Gas joined in 1993
   - Angror - 1 well drilled in January 1994 (170 km south-west of Sihanouk Ville in 70 m of water)
   - Testing operation of four zones completed in April 1994
   - Gas and condensate flows from tests

3 . **Block III** (approximately 3,669 km^2)
- Awarded in December 1991 to Campex
- Agreement for exploration and production between MIME and Japan Petroleum Exploration Co. Ltd. (JAPEX)
- Apsara -1 well drilled in late 1993 (small quantities of oil and gas during testing)
- Deveda -1 well drilled in early 1994 (not tested, plugged and abandoned as a dry well)

4 . **Block IV** (approximately 4,595km^2)
- Awarded in November 1991 to a consortium led by Premier Oil Pacific Ltd.
- Geophysical studies conducted in 1993 and 1994 (oil and gas flowed during testing)

5 . **Blocks V, VI** and **VII** (average size 4,000 km^2 each)
- Bids have been received and are being evaluated

- ***Onshore Blocks:***

1 . 19 Blocks (average size 5,000 km^2)
- None have been awarded
- Block 10 has been offered for tender
- Bids have been received and are being evaluated

2.1.1.4 Discharge from upland and lowland activities

In Cambodia, almost all cities, towns and factories are built close to the main waterways in both the central and coastal areas as it is easy to use the water for domestic and other purposes and to discharge all kinds of waste into the waterways. Most of the wastewater coming from the factories and cities or towns has been discharged through the drainage system into surrounding ponds or reservoirs, and then to the rivers or to the coastal waters without treatment. Meanwhile, the solid waste generated in the cities and towns is disposed in an improper way in open burning landfills or illegal dumps into water bodies.

The major discharge from upland and lowland activities into waterways includes: domestic sewage, municipal solid waste and soil erosion from the high plateau surrounding the waterways. Land-based discharge into the river systems and coastal waters consists of industrial waste, agricultural waste, mining waste and oil waste.

- ***Domestic sewage***

The sewage management in large cities and towns is extremely poor. All large urban centres are partly served by combined sewage and storm drainage systems that consist of conventional flush toilets, sometimes draining into a septic tank. Almost all the sewerage systems have not been maintained over the past three decades and now are in a state of disrepair with 80 per cent of the pipes being damaged. The sewage is not discharged to treatment systems, but to waterways or water bodies, such as the Mekong and Tonle Sap Rivers, which are directly used for drinking water, bathing, swimming and irrigation. As a consequence of the improper discharge of sewage, waterborne diseases, such as cholera, typhoid and enteritis, are common throughout the country. Nearly two thirds of all deaths of children under five are associated with waterborne diseases.

To date, the sewage from the three population centres of the coastal zone has been discharged through the drainage system to open canals or rivers and then to coastal waters without treatment. The estimated amount of sewage discharged from the coastal cities and towns is shown in table 2.7.

Table 2.7 Amount of sewage discharged from urban centres in the coastal zone

Cities and Towns	**Receiving source**	**Population**	**Daily amount of sewage** (m^3 / day)	**Content of pollution** (T / day)
Koh Kong Town	Sea	24,150	2,173	BOD: 1.21 TSS : 2.65 Total N: 0.22 Total P: 0.06
Sihanouk Ville	Sea	55,440	5,544	BOD: 2.77 TSS : 6.10 Total N: 0.50 Total P: 0.14
Kampot Town	Sea	30,150	2,713	BOD: 1.50 TSS : 3.32 Total N: 0.27 Total P : 0.08
Total		**109,740**	**10,430**	**BOD: 5.48** **TSS : 12.07** **Total N: 0.99** **TOTAL P: 0.28**

Source: Ministry of Environment, Department of Pollution Control, 1997.

In the central area, there are six major urban centres with a population of more than 100,000 located along the Mekong, Tonle Sap and Bassac Rivers, as presented in figure 2.5. The estimated amount of domestic sewage discharged from the main cities and towns into waterways is shown in table 2.8.

There is only one sewage treatment system in Battambang Province, but it has not functioned since 1996 because of financial and technical problems. To date, there has not been a real plan to build a sewage treatment system in the cities or towns located in the central area.

Table 2.8 Amount of sewage discharged from urban centres in the central area

Cities and towns	**Receiving source**	**Population**	**Daily amount of sewage** (m^3 / day)	**Content of pollutant** (T/ day)
Phnom Penh City	Bassac River Tonle Sap R.	1,100,000	110,000	BOD: 55.00 TSS : 121.00 Total N: 9.00 Total P: 2.75
Kampong Chham Town	Mekong River	272,000	24,300	BOD: 13.60 TSS : 30.00 Total N: 2.45 Total P: 0.70
Kandal Town	Bassac River	173,000	15,570	BOD: 8.65 TSS : 19.03 Total N: 1.56 Total P: 0.43
Battambang Town	Tonle Sap Lake	128,000	11,520	BOD: 6.40 TSS : 14.08 Total N: 1.15 Total P: 0.32
Siem Reap Town	Tonle Sap Lake	102,000	9,180	BOD: 5.10 TSS : 11.22 Total N: 0.92 Total P: 0.26
Kompong Thom Town	Tonle Sap Lake	100,000	9,000	BOD: 5.00 TSS : 11.00 Total N: 0.90 Total P: 0.25
Total		**1,875,000**	**179,570**	**BOD: 93.75** **TSS: 206.33** **Total N: 15.98** **TOTAL P: 4.71**

Source: Ministry of Environment, Department of Pollution Control, 1997.

- ***Solid waste***

(i) Waste generation by selected types of waste

The Government recognizes that the management of solid waste in urban centres is a major urban environmental problem. Although Cambodia does not have high consumption or high waste generation, almost all urban areas have significant waste disposal problems that are continuing to grow in the absence of environmentally sound management policies and actions. Unsightly piles of rubbish along the streets are common. Within and without the collection areas, all kinds of wastes are disposed of in open areas, roads, rivers, streams, lakes, borrow pits and private properties. This contributes to unsanitary conditions in urban centres such as unpleasant smells, blockage of drains resulting in flooding, and rainwater run-off from refuse causing surface water pollution.

The estimated amount of solid waste generated, collected, uncollected, and disposed of into waterways in major urban centres of the central and coastal areas is shown in table 2.9.

Table 2.9 Solid waste in major urban centres

Cities and towns	**Population**	**Estimated solid waste amount** (T/day)	**Collected solid waste** (T/day)	**Uncollected solid waste** (T/day)	**Disposed solid waste into water system** (T/day)
Phnom Penh City	1,100,000	650.0	396.0	264.0	158.40
Kampong Chham Town	272,000	136.0	81.6	54.4	32.64
Kandal Town	173,000	86.5	51.9	34.6	20.76
Battambang Town	128,000	64.0	38.4	25.6	15.36
Siem Reap Town	102,000	51.0	30.6	20.4	12.24
Kompong Thom Town	100,000	50.0	30.0	20.0	12.00
Koh Kong Town	24,150	12.1	7.3	4.8	2.90
Sihanouk Ville City	55,440	27.7	16.6	11.1	6.64
Kampot Town	30,150	15.1	9.1	6.0	3.60
Total	**1,984,740**	**1,102.4**	**661.5**	**440,9**	**264.50**

Sources: Ministry of Environment, Department of Pollution Control, 1997;
Municipal and town authorities of these cities and provinces, 1996.

(ii) Collection

All provincial towns have limited collection services. Most of the other towns have collection services operated either by the Department of Public Works and Transport (DPWT) or the Provincial Administration. The problem in all towns is the service ability of vehicles. All are old and subject to frequent breakdowns.

In Phnom Penh, the solid waste collection service of the municipality is also served by a private company. Between 100 and 115 truck loads of waste are delivered to the open dump each day. This amounts to approximately 1300 m^3 or 500 to 650 tons per day. Reportedly, all the urban population receives a solid waste collection service, but in reality it is estimated that only about 60 per cent of the waste is collected. Uncollected waste is evident along the streets and in the drains and watercourses throughout Phnom Penh.

With further urban development, the problem with the present collection system in Phnom Penh and urban centres including the coastal cities and towns will increase. This problem will result in serious water pollution in some public water areas in the future.

(iii) Disposal

Almost all urban centres have a very significant solid waste disposal problem. In general, people in urban centres like to use waterways as convenient disposal sites. Solid waste generated in major cities consists mostly of organic matter from residential, commercial and industrial sources and from medical facilities. About 60 per cent of the total amount of solid waste generated in main cities and town is collected.

Generally, the collected solid waste in urban centres is transported to open burned dump sites without soil cover. This affects the quality of the waterways by leaking the water from the decay of waste and run-off during the rainy season. The remainder, about 50-60 per cent, of uncollected waste is illegally dumped into vacant lots, swamps, the sewerage system or directly into the public water areas. One of the major risks associated with open dumps is the spread of disease pathogens and chemical contaminants in closed waterways through leaking water and water run-off resulting in major public health problems and water contamination.

- ***Soil erosion***

In Cambodia, the major root causes of soil erosion are deforestation, poor agricultural activities and gemstone mining activity in the border areas between Cambodia and Thailand. High soil erosion has taken place in the north-east mountain ranges and high plateau along the main tributaries of the Mekong River, and in the north-west high plateau from where sediment flows into the Tonle Sap Lake.

The soil erosion in the north-west highlands, where illegal deforestation and gemstone mining illegal activities have continued, is the major root cause of sedimentation in some rivers, especially in the Tonle Sap Great Lake, directly impacting the overall environment of the lake, particularly fish production. The sedimentation of the lake has reportedly increased dramatically in the last two decades. In the 1960s sedimentation rates of 2 cm a year were recorded (FAO 1991). Increased sedimentation rates in the lake are attributed to a number of factors including: deforestation in the upper reaches of the Tonle Sap watershed and the flooded forest, gemstone mining in Paylin City, and increased Mekong silt load owing to deforestation in other parts of the Mekong basin. This sedimentation flows downstream the Mekong delta to southern Viet Nam and discharges into the South China Sea.

In addition to the sedimentation problem of the lake, soil erosion in the mountain ranges also causes some estuaries to become shallower from year to year. However, the sedimentation survey in the rivers of the coastal area has not yet been conducted.

Table 2.10 Number of factories in main urban centers and coastal provinces

Provinces & cities	Mining & quarrying	Manufacturing								Total	Electricity gas & water	Total
		Food beverages & tobacco	Textile & wearing apparel	Wood & wood products	Paper & Paper products	Chemicals rubber & plastic products	Non-metallic mineral products	Basic metals	Fabricated metal products			
Phnom Penh City	0	68	128	12	10	33	53	6	37	347	1	348
Kampong Cham	1	19	1	6	0	1	15	0	0	43	2	45
Kandal	1	24	11	9	2	5	54	0	2	108	0	108
Battambang	0	16	2	0	0	0	15	0	2	35	2	37
Siem Reap	0	8	0	0	0	0	15	0	1	24	2	26
Kampong Thom	0	5	0	1	0	0	20	0	0	26	0	26
Koh Kong	1	1	0	1	0	0	1	0	0	4	2	6
Sihanouk Ville	0	12	6	7	1	1	3	0	0	30	2	32
Kompot	96	3	0	1	0	0	4	0	0	104	2	106
Total	99	156	148	37	13	40	180	6	42	721	13	734

Source: Ministry of Industry Mines and Energy, Department of Planning, June 1998.

- *Industrial wastes*

Cambodia is not a heavily industrialized country. Light industry predominates, such as: food, beverages, tobacco, textiles, wearing apparel and non-metallic mineral products (table 2.10).

The rapid growth of factories (table 2.11 and figure 2.6) in urban areas of the country can cause a problem of water pollution because almost all factories have been improperly built and lack waste management facilities. Industrial solid waste is disposed at the open burning dump sites intended for domestic waste. In addition, wastewater from the factories is discharged into public sewers or directly into water bodies in both the central and coastal zones without any treatment.

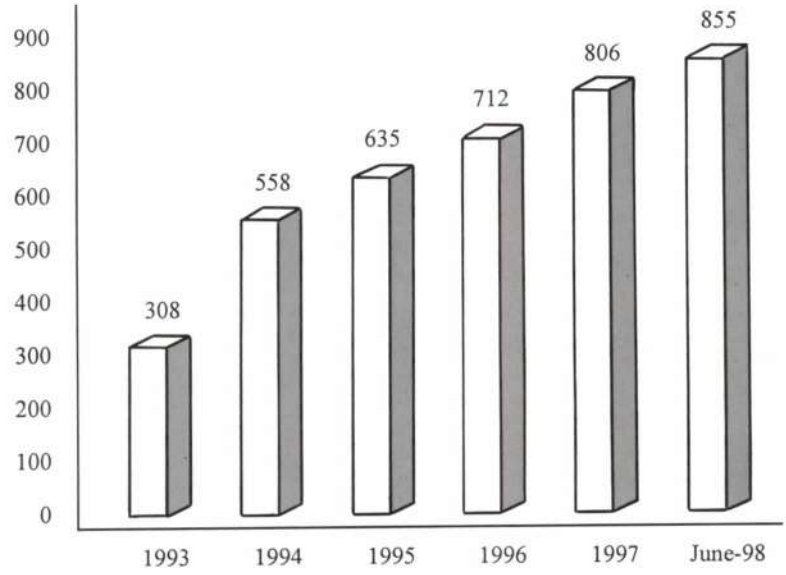
To date, the data on the amount and pollutant content of industrial waste have not been available because the industrial monitoring and surveillance has not been carried out.

Table 2.11 Industrial growth from 1993 to June 1998

Type of industry	**1993**	**1994**	**1995**	**1996**	**1997**	**06/1998**
Mining and quarrying	99	101	101	102	102	102
Food, beverages & tobacco	77	146	164	189	198	204
Textiles & wearing apparel	10	26	39	55	111	149
Wood and wood products	19	21	51	62	68	70
Paper and paper products	3	8	8	11	13	13
Chemical, rubber and plastic products	12	22	26	34	39	40
Non-metallic mineral products	55	179	188	191	201	202
Manufacture of basic metals	3	5	5	6	6	6
Fabricated metal products	7	24	27	35	41	42
Other manufacturing industries	0	1	1	2	2	2
Electricity, gas and water	23	25	25	25	25	25
Total	**308**	**558**	**635**	**712**	**806**	**855**

Source: Ministry of Industry, Mines and Energy, Department Planning, June 1998.

Figure *2.6* Industrial growth from 1993-June, 1998 in Cambodia



- ***Agricultural wastes***

In Cambodia, agricultural wastes include residues of pesticides and fertilizers used for cultivation activities, and waste from aquaculture activities especially in the coastal area.

The total cultivated area in Cambodia is about 1.9 million hectares (World Bank 1994). In order to increase production yields, Cambodian farmers were encouraged to use chemical fertilizers and pesticides. The upward trend of indiscriminate use of these chemical compounds is of increasing concern as residues of these substances are carried by surface run-off from cultivated areas to water bodies, thus causing water pollution. This problem is taking place in some provinces in the Mekong and Tonle Sap catchment areas, such as Kompong Chham, Battambang, Siem Reap, Prey Veng and Takeo provinces.

To date, information on the use of pesticides and fertilizers, such as type and amount, is not available because there has not yet been any monitoring or research on the use of these substances. In addition there are no regulations on the management of pesticide and fertilizer use.

The main aquaculture activity discharging high amounts of toxic waste into water bodies is shrimp farming which was introduced to the coastal provinces of Cambodia in the latter half of the 1980s, primarily in Koh Kong near and inside the mangrove forests. In 1994 there were 840 hectares of shrimp farming in Koh Kong province, as presented in figure 2.7. The shrimp farms in Koh Kong are creating serious negative side effects, such as shrimp disease and self-pollution. Furthermore, the shrimp culture mostly generates toxic effluent, discharging directly into the adjacent areas and the sea without treatment. It is likely that sites in Sihanouk Ville and Kampot will be developed for shrimp farms in the near future.

Two types of shrimp farming are practised in Cambodia: extensive and intensive shrimp farming. Extensive farms are primarily found in Kampot province where the natural tidal cycle is used to catch shrimp fry for growth in ponds in the remaining mangrove forest. This type of farming has low productivity, but does not have major impacts on the environment. Intensive shrimp farming is primarily located in Koh Kong province where the mangroves are cleared to make way for ponds to raise shrimp. This type of farming involves large capital investments in infrastructure, seed, feed, chemicals and antibiotics, but it can also lead to enormous profits in the short term. As has happened in all other areas where this sort of aquaculture has been developed without an adequate understanding of the local ecosystem, many of the farms (70–80 per cent) are now unproductive and have been abandoned. The environmental impacts of intensive shrimp farming involve decline in water quality, development of acid sulphate soils and indirect losses to fisheries because of the destruction of mangroves.

- ***Oil waste***

In Cambodia, oil waste in water bodies mainly comes from navigation activities, boat washing and repairing, and daily operations related to fuel use. Another major source of oil pollution in water is the disposal of vehicle oil.

The risk of oil spills in the South China Sea potentially affecting Cambodia's exclusive economic zone (EEZ) primarily stems from three sources:

(a) Accidental spills and leaks from the petroleum storage facility during the transfer of product in Sihanouk Ville;
(b) Spills, leaks and improper waste management from petroleum exploration and exploitation activities;
(c) Spills and leaks from vessels transporting petroleum products en route to Thailand or Japan.

2.1.1.5 Ports and harbours- Maritime transport

In the coastal area, there are eight minor harbours of which four are located in Koh Kong province, two in the estuary of Sihanouk Ville, and two in Kampot province. They are used for transit or shipping goods among the coastal provinces and for the docking of fishing boats. Some of the habours can accommodate vessels loaded up to 15 tons. The provincial authorities have expressed a desire to deepen some harbours so that up to 30-ton ships can access the harbours.

In the coastal area there is only one international port located at Sihanouk Ville, Cambodia's only deep-water maritime port, which was built in 1956 with a total capacity of 1.2 million tons a year. It handles oil and shipment in bulk. Four 1,000-ton vessels can be accommodated, but they are restricted to 7.6 metre draft plus the height of the tide on the east of the pier and 9.5 metre draft on the west side. There are various other berths available for smaller vessels. A plan for expansion was prepared in 1965, but never executed after the political settlement (1993). The port plays a key role in handing the import of goods for the reconstruction and development of the country so that new wharves have been built and access channels are being deepened.

At present, it has modern equipment to lift, load and unload containers. In 1994 imported goods totalled 439,738 tons, and exported goods 107,574 tons, a total import and export of 547,312 tons. It is expected that growth in imports and exports at Sihanouk Ville port will reach 1,200,000 tons in the year 2000 (see table 2.12).

Table 2.12 Activities of Sihanouk Ville Port

Year	Amount of imported goods (ton)	Amount of exported goods (ton)	Total (ton)
1992	201,530	77,370	278,900
1993	299,080	152,120	451,200
1994	439,738	107,574	547,312
1995	480,500	119,500	600,000
1996	532,650	187,350	720,000
2000	-	-	1,200,000

Source: Ministry of Public Works and Transportation, Port Authority, 1997.

The environmental issues are mainly related to the risks of transporting hazardous goods in which oil and chemical substances are the most important.

2.1.1.6 Seabed exploration and exploitation

In addition to offshore exploration of oil and gas, there is some small-scale coral reef exploitation in some areas off Sihanouk Ville. There is no information on other activities relating to seabed exploration and exploitation.

2.1.1.7 Marine dumping

Currently, information on marine dumping is not available in Cambodia.

2.1.1.8 Atmospheric inputs to the aquatic environment

There has not yet been any information or reports about atmospheric inputs to the marine and coastal systems of Cambodia.

2.1.2 Pollution hot spots

In Cambodia, the pollution hot spots are not in freshwater or seawater areas because economic development is still low compared with neighbouring countries, especially in the industrial sector. However, economic development is likely to increase in the near future and that will create pollution hot spots in some areas of the country.

2.1.3 High risk and sensitive areas

(a) High risk areas

In Cambodia, the high risk areas are Phnom Penh City and Sihanouk Ville, as presented in figure 2.8.

- ***Phnom Penh City :*** Phnom Penh is the capital of the country with a population of about 1,100,000 (1997). There are 181 factories including moderate and small size ones, and about 1,200 handicrafts. It is expected that this city will have a high potential for development in all sectors in the near future.

The capital is located along the banks of the Tonle Sap River and Bassac River, where there is a small international port accessible to vessels from the South China Sea. Less than half of the port's total capacity (450,000 tons a year) is currently being used.

The solid waste generated in Phnom Penh City is estimated to be about 650 tons a day, of which about 264 tons is uncollected. About 50-60 per cent of the uncollected waste is disposed into the sewerage system or directly into the water bodies. Meanwhile, large amounts of pollutants contained in the city's sewage are discharged into the Tonle Sap River and Bassac River, as follows:

BOD:	20,075 tons / year
TSS:	44,165 tons / year
COD:	34,130 tons / year
Total N:	3,285 tons / year
Total P:	1,000 tons / year

- ***Sihanouk Ville:*** This is the biggest city in the country's coastal zone. The urban population is about 55,440 (1997) with a high population density of 152 persons per square kilometre. There are 20 factories and about 180 handicraft businesses. It is expected that this urban centre will have a high potential for industrial development in the near future.

The city has a port with a capacity of 1,200,000 tons, activity in imports and exports reaching full port capacity (1,200,000 tons) in the year 2000. There are also two harbours, one for serving fishery activities and the other for commercial trading activities among the coastal provinces and between Cambodia and Thailand.

The urban area of Sihanouk Ville generates household solid waste of about 30 tons per day, of which about 9 tons per day is uncollected. In addition, the coastal waters off Sihanouk Ville receive a significant amount of pollutants caused by the direct discharge of sewage into the seawater, as listed below:

BOD :	1,011 tons / year
COD :	1,720 tons / year
TSS :	2,226 tons / year

(b) Sensitive areas

In Cambodia, the sensitive areas are found in the urban centres located around Tonle Sap Lake such as: Kompong Chhnang, Pursat, Battambang, Siem Reap and Kompong Thom province, as presented in figure 2.8.

All the towns of these provinces are located close to the tributaries of the Tonle Sap Lake whose water, and that of its tributaries, is contaminated by the discharge of sewage and the disposal of solid wastes into the water. The water quality degradation of these water bodies takes place during the last three months of the dry season when the water bodies become shallow and the dilution level of the water bodies is low.

2.1.4 Transboundary effects of pollution

2.1.4.1 Biodiversity

It is clear that the sewage from cities, urban areas and floating houses is a major source of pollution in some rivers. However, industrial wastes remain low and do not impose serious effects on biodiversity. There might be some impacts on spawning/nursery grounds. Unfortunately, there have not been any systematic studies and research on the effects of these issues.

2.1.4.2 Habitats

The effects of pollution can cause some damage to aquatic habitats, such as mangroves, coral reefs, seagrasses, as they can make their natural growing processes impossible.

Despite the absence of research, it can be confirmed that there is a low level of negative impacts from pollution because the sources of pollution are small scale.

2.1.4.3 Public health

The effects of pollution on people's health could be significant. However, studies and research have not been conducted so far in critical places such as populated areas.

The discharges of untreated human and animal wastes are the main source of the spread of waterborne diseases in Cambodia, such as typhoid and cholera. A report of the World Health Organization (WHO) in 1996 showed that nearly two thirds of deaths among children under five are associated with waterborne diseases.

We need comprehensive studies and monitoring of public health in order to understand the effects of pollution.

2.2 FRESHWATER SHORTAGE AND DEGRADATION OF ITS QUALITY

2.2.1 Surface water

2.2.1.1 Sources of surface water and current status

- ***Sources of surface water***

In Cambodia there are two major sources of surface water. The first one is rainfall which is considered as a local source. The second one comes from the Mekong River which enters Cambodia from the Lao People's Democratic Republic and which is important for the central region of the country.

The average annual rainfall varies across the country from between 1,000 to 2,500mm. Rainfall in the central area covering the Tonle Sap River system and the Lower Mekong River system averages 1,200 to 1,900 mm. annually. East of the Upper Mekong River system, rainfall is generally between 1,800 and 3,000 mm (figure 2.9). The heaviest rainfall, over 3,000mm a year, occurs along the coastal lowland in the west.

The estimated total volume of rainfall in Cambodia is about of 426 billion m^3 per year, of which only 212.5 billion m^3 (49.9 per cent) flows into water bodies. The remainder is subject to evaporation and evaportranspiration, recharging groundwater. It is used for other supplies, but data on the amount are not well estimated (Irrigation Rehabilitation Study in Cambodia, June 1994).

Apart from rainfall, surface water comes from the Mekong River which originates in the Sino-Tibetan plateau. The Mekong River's average annual discharge entering Cambodia is more than 300 billion m^3 and it is estimated that with the contributions of the downstream tributaries, about 500 billion m^3 discharge to the South China Sea annually (FAO 1994).

- ***Current status of surface water***

According to the rainfall and hydrology data mentioned above, the quantity of surface water in the three subregions of the country may be enough for agriculture and urban centre supplies.

Concerning the monitoring of surface water quality, the Mekong Secretariat has been monitoring water quality in the mainstream and major tributaries of the Mekong River system and the Tonle Sap River system since August 1993. Water samples have been taken monthly. The nine sampling points located in the mainstream of the Mekong, Bassac and Tonle Sap Rivers and Tonle Sap Lake are shown in figure 2.10.

So far, no data have been available on the tributaries of those rivers and on the rivers in the coastal area. Moreover, the BOD, heavy metals, PCBs and pesticides have not yet been measured.

Based on the results of the river water quality analysis made by the Mekong Secretariat, it could be seen that the total suspended solids at five sampling points in the Mekong River system was high during August and September with its average varying from 400 to 450 mg/l, as presented in figure 2.11. In 1996, the maximum level of TSS reached 685 mg/l. Apart from the suspended sediment load, the water quality of the Mekong River system is regarded as satisfactory for aquatic life with an average of dissolved oxygen varying from 6 to 7.5 mg/l . Eutrophication of the surface water in the lower Mekong Basin is not considered to be a problem at present (Mekong Secretariat 1995).

The water quality analysis showed that the water quality of some segments of the Tonle Sap River system was considered to be a slight problem with dissolved oxygen lower than 2 mg/l during March and May 1997, as shown in figure 2.12. According to a visual survey over the last three years, it was found that the Tonle Sap Lake had a moderate eutrophication problem during the last dry season, from April to May, when the lake's water was shallow.

2.2.1.2 Demand for its use (by sector)

The surface water is used for different sectors as follows:

(a) Agricultural sector: The demand for surface water use in this sector is the highest compared with other supplies. Rice farming is the largest water user, while other crops are the second largest water demander in this sector. Apart from rice and crop irrigation, water is also used for aquaculture farming;

(b) Domestic sector: At present, the domestic need for water is on a small scale. However, it will grow rapidly as the development rate increases, especially in the major urban centres such as: Phnom Penh, Sihanouk Ville, Siem Reap and Battambang towns;

(c) Industrial sector: In Cambodia, the industrial development is still weak, therefore this sector is a smaller user than the domestic sector.

The data on surface water use by sector is not available.

2.2.1.3 Impact areas for shortage or low quality surface water

- ***Surface water shortage***

In general, although Cambodia's surface water source has much potential as already mentioned in section 2.1.1.1, water shortages for agricultural irrigation and water supply in urban and rural areas have taken place in some cities and provinces (see figure 2.13).

Shortages of surface water for irrigation and domestic water supply take place almost every year in Takeo and Kompong Speu provinces. The main problem of water shortage in these provinces is caused by low rainfall, small and less numerous surface water sources and a lack of an irrigation system for storing water. Moreover, most of remote rural areas in these provinces are now facing a surface water shortage for domestic supply in the dry season.

Apart from these provinces, surface water shortages for agricultural irrigation has occurred in some provinces located in the catchment areas of the Mekong and Tonle Sap River systems, such as: Prey Veng, Svay Rieng, Komppong Cham and Battambang where the rainfall varies from 1,500 to 2,500.mm. As already mentioned, the problem of water shortage in the central catchment area is caused by the lack of management of stored basin and irrigation systems.

The surface water shortage for water supply has also occurred in some urban centres of the three coastal provinces in the dry season. The reason for the shortage is the lack of basins or reservoirs for surface water storage and shallow existing lakes or reservoirs because of soil erosion.

- ***Low quality surface water***

In general, the degradation of surface water quality in Cambodia has occurred in the downstream part of some urban centres during the dry season (from March to June).

According to a surface water quality analysis result carried out by the laboratory of the Mekong Secretariat in Phnom Penh, low quality surface water with low dissolved oxygen has been found in the Tonle Sap River system in the dry season, for example downstream Tonle Sap River, upstream Bassac River, the lower courses of Stung Sangker, Stung Siem Reap and some parts of the Tonle Sap Lake (see figure 2.13).

Quality degradation of these surface waters is caused by the discharge of sewage and industrial wastewater directly into streams without treatment, and the disposal of all kinds of solid waste, which causes dissolved oxygen to fall (down to 1 mg/l), and the presence of more disease agents (fecal coliform bacteria of more than 1 million /1).

The shortage and quality degradation of surface water has affected the development of the national economy, the people's health and the ecosystem, causing serious poverty.

2.2.1.4 Causes of issues and problems

- ***Causes of surface water shortage***

In Cambodia, the problem of surface water shortage for agricultural irrigation and domestic water supply purposes has been caused by several factors, as follows:

(a) There is no national policy for the sustainable management of surface water;
(b) Deforestation increases annually in the high plateau surrounding the central plains, causing serious soil erosion that makes water bodies shallow. Moreover, deforestation also causes low rainfall;
(c) A lack of reservoirs or lakes for storing surface water for use in the dry season;
(d) A lack of or poor irrigation systems in the country;
(e) The use of surface water for irrigation as well as for water supply in urban centres is uneconomical and irresponsible;
(f) A lack of laws and other regulations on surface water management and protection; existing laws and regulations do not stipulate clearly about the control of surface use;
(g) Overlap and gaps of responsibility for the management of surface water use among government agencies, leading to uncoordinated and conflicting duties;
(h) Governmental staff capacity in the management of water use is still low;
(i) Financial constraints for developing and rehabilitating reservoir and irrigation systems.

- ***Causes of the quality degradation of surface water***

In general, the degradation of the quality of surface water occurs downstream in the major urban centres. It is caused by the following factors:

(a) Poor solid waste management with uncontrolled disposals, and lack of treatment systems and facilities for collection and transportation;
(b) The disposal of about 30 per cent of uncollected solid waste into water bodies; moreover, almost all dump sites are open-burning without a system protecting against leaked water;
(c) The direct discharge of sewage and untreated industrial wastewater into water bodies;
(d) Lack of wastewater treatment systems and sewerage systems that have not been reconstructed and restored;
(e) Lack of control and poor management of wastewater discharge;
(f) Lack of facility for monitoring the surface water quality such as laboratory equipment and permanent monitoring stations;
(g) No laws and regulations relating to solid waste management and wastewater control;
(h) Low capacity by government staff to control and monitor solid waste disposal and wastewater discharges;
(i) Lack of finance to build wastewater treatment plants and maintain the sewerage system in urban areas.

2.2.1.5 Impacts of global change

There has been no scientific research on the effects of climate change on the surface water in Cambodia. However, it has been noted that in the last two years there have been some changes in climate such as:

- The temperature of the air has increased, especially in the last dry season of 1998 (March, April, May) when it reached 40.5 ^{0}C during the day;

- The cold season (December to February) was lost last year;

- The amount of rainfall has decreased in the rainy season of the last two years throughout the country and the duration of the rainy season has been shorter than in the past.

It would appear from this that the surface water resources in Cambodia have been slightly impacted by global change. Therefore, scientific research on the effect of global climate change on the surface water resources should be carried out.

2.2.1.6 Proposed interventions and sustainable rates of extraction

The proposed intervention and sustainable rates of extraction of surface water use are as follows:

(a) Setting up an effective national policy on water sources and surface water resources protection and management;
(b) Developing laws and regulations on water and water resources management;
(c) Setting up water quality standards and effluent standards;
(d) Establishing and implementing a master plan to integrate management in various uses such as irrigation, watershed control, domestic water supply and flood control;
(e) Developing a surface water quality monitoring system;
(f) Improving the control of wastewater discharges into public water areas;
(g) Prohibiting all kinds of water and water resources uses without permission except for household use;
(h) Insisting that all projects affecting the quantity and quality of water and water resources submit an environmental impact assessment report to the Government;
(i) Strengthening the capacity-building of the government staff in the field of water resources management and water pollution control;
(j) Improving public awareness on water and water resources protection and conservation.

2.2.2 Groundwater

2.2.2.1 Groundwater aquifers and current status

Groundwater may be an important resource for the economic development of the country. But its utilization is still limited to rural and urban domestic supplies, for small industry and minor irrigation, mostly in the dry season.

As far as the groundwater aquifers are concerned, there is insufficient information on this natural resource because there has not yet been a comprehensive investigation.

Some studies of groundwater aquifers were conducted, as follows:

- In 1958, the United States geological survey group carried out the first study of Cambodian groundwater in the central area (Kompong Cham and Battambang provinces), and coastal area (Kampot province). The results of the study showed that moderate supplies up to 22.7 m^3/hr could probably be obtained in a number of the study areas.

Based on first study result, USAID developed a drilling programme from 1960 to 1963. Its purpose was to describe and evaluate the availability of groundwater. The programme uses information from a total of over 1,000 drilled and hydro-jetted holes, covering the whole country

except the north-eastern provinces. The depth ranged from 2 to 209 metres, with an average depth of 23.2 metres. The yields from productive wells ranged from 0.066 to 178.32 m^3 / hr. The programme came to the following important conclusions on groundwater aquifers:

(a) Groundwater can provide an important dry season supplement to surface water sources;
(b) Groundwater can be a principal source for small industry, minor irrigation, and domestic and rural needs;
(c) More than half the country remains to be explored by drilling;
(d) Large capacity wells will be possible but rare, and will obtain most of their water from nearby sources of induced recharge, such as streams or lakes;
(e) In general, because of the heavy jungle, the presence of laterite soils and the prevalence of silt and clay in the alluvium, infiltration rates are low;
(f) Because of the coarseness of the sand and sandstone, storage coefficients and transmissivity are commonly low;
(g) However, indications are that there is sufficient groundwater storage to provide sustained water yields during the dry season;
(h) Potential recharge during the wet season is more than adequate in most of Cambodia;
(i) Production capacity of groundwater can be about 17,600 million m^3 a year.

- In 1992, a second study was conducted in Kompong Thom province located in central Cambodia. The study result showed that there were aquifers in study area of 432 square kilometres. One is a porous lateritic layer immediately under the top soil, and the other is composed of sandy and gravely alluvium in the low land below elevations of 20 metres above mean sea level. The specific yield of the aquifers is small, approximately 15m^3/day (lateritic strata) and 50m^3/day (sandy layer) assuming that the draw-down is 5 metres and the influence radius is 300 metres. The aquifers have high electric conductivity: 90-1,050 (at 80°C) micro-ohm/m which correspond to salt contents around 0.00014 – 0.61 per cent. The water is generally easily accessible. It lies only 1-2 metres below ground in the rainy season. Farmers dig shallow wells and fully utilize the water for domestic purposes.

- In 1994, a third study was conducted in the coastal provinces (Sihanouk Ville and Kampot). The study result showed that drawdown tests indicated a pumping rate for individual production wells of not more than 20m^3/hr to avoid over-pumping of the wells. Although not all wells have been sampled and analysed, salinity concentrations too high for drinking purposes were measured in 9 of the 87 wells in Sihanouk Ville and in 5 of the nearly 1,000 wells in Kampot.

2.2.2.2 Demand for its use (by sector)

In Cambodia, groundwater is used for urban and rural domestic water supplies, for agricultural irrigation and for industrial purposes. Currently, the demand for groundwater use for urban and rural water supply is ever-increasing because the surface water supplies in these areas are not available or because the surface water quality has deteriorated.

Since 1983, the United Nations Children's Fund (UNICEF) has had a drilling programme to construct wells for urban and rural water supplies in cooperation with the Ministry of Health, and then in 1993 with the Ministry of Rural Development. The number of wells drilled by UNCEF and non-governmental organizations in each year from 1983 to 1996 and in each province are presented in tables 2.14 and 2.15 respectively.

Table 2.13 Number of wells constructed by UNICEF and non-governmental organizations, 1983-1996

Year	Number of wells
1983	10
1984	24
1985	88
1986	352
1987	804
1988	1,367
1989	1,025
1990	826
1991	1,097
1992	1,833
1993	1,745
1994	1,687
1995	1,303
1996	224
Total	12,385

Source: Ministry of Rural Development, 1997.

The total number of wells and the total volume of groundwater exploited for urban and rural water supplies in the whole country is not available because the exploitation of groundwater has not been registered yet in Cambodia.

The use of groundwater for agricultural irrigation especially for rice paddy has been introduced since 1993 in Takeo province where the surface water is inadequate for rice paddy irrigation. In the last three years, the use of groundwater for rice paddy has become widespread in Prey Veng, Svay Rieng and Kompong Cham provinces.

The demand for groundwater use for the industrial sector is the smallest. Groundwater has only been used in some factories and handicraft establishments where surface water supply is inadequate or of low quality.

Table 2.14 Number of wells drilled by UNICEF and non-governmental organizations in each province, 1983 -1996

Name of province	Number of wells
Phnom Penh	1,243
Kandal	2,237
Kompong Speu	1,306
Takeo	1,671
Kampot	674
Kompong Chhang	1,040
Kompong Cham	1,212
Pre Veng	1,121
Pursat	194
Sihanoukville	87
Battambang	664
Banteay Meanchey	91
Siem Reap	292
Preah Vihear	30
Kompong Thom	32
Koh Kong	5
Ratanakiri	18
Kratie	46
Svay Rieng	422
Total	12,385

Source: Ministry of Rural Development, 1997.

2.2.2.3 Impact areas of shortage or low quality groundwater

- ***Groundwater shortage***

Owing to the abundance of surface water, which plays an important role in recharging the groundwater, the use of groundwater by sector is on a small scale compared with other countries. Therefore, groundwater shortages occur in only a few areas of the country, such as the central part of the border between Battambang and Pursat provinces, the north-west part of Kompong Speu province, and the northern part of Kompong Thom (see figure 2.14).

The report of the drilling programme conducted by UNICEF and the Ministry of Rural Development shows that the groundwater aquifers of these areas are too deep to exploit (deeper than 150 metres). It is believed that people in these areas use the small streams, lakes and ponds for domestic water supply and for their animals. This is causing an epidemic disease problem in these areas.

- ***Low quality groundwater***

A scientific study of groundwater quality has not yet been carried out. Therefore, detailed information on the areas where the quality of groundwater has deteriorated is not available. However, based on the report from UNICEF's drilling programme, it can be seen that the quality of the groundwater in most areas of the country is generally satisfactory although high iron concentration and increased salinity levels have been encountered in the following provinces: Svay Rieng, Prey Veng, Kandal, Banteay Meanchey, Battambang, Kompong Speu and Takeo.

2.2.2.4 Causes of issues and problems

The causes of groundwater shortage and quality deterioration include:

(a) *Over-exploitation of groundwater*: Groundwater levels may be lowered by over pumping. Pumping from deeper rock aquifers such as limestone or sandstone may cause springs to dry up in the dry season. This may affect base flows in streams and rivers with subsequent effects on small-scale irrigation that relies on these flows for supplementary water. In addition this may cause saline intrusion, particularly in the coastal area.

(b) *Lack of a national policy for groundwater management:* The groundwater source has been paid little attention. Groundwater use is free and has not yet been required to have permission or licence.

(c) *Deforestation*: This may affect the process of groundwater recharge as the top soil becomes tight and hard and the rainfall decreases.

(d) *Lack of laws and regulations relating to groundwater quality protection*: Household solid waste is disposed at dumping sites without facilities protecting against contaminated water leaking into groundwater. Furthermore, industrial waste containing hazardous substances and trace elements is disposed at the dumping sites without pre-treatment. This can lead to pollution of the groundwater.

(e) *Lack of groundwater quality control*: Groundwater quality has not been analysed yet because of a lack of laboratory equipment and financial constraints.

2.2.2.5 Impacts of global climate change

Information on the effects of global climate change on groundwater is not available because of a lack of scientific research and investigation.

2.2.2.6 Proposed interventions for sustainable rates of extraction

In order to have a sustainable management of groundwater use, the following interventions have been proposed:

(a) To set up a policy and master plan for managing groundwater exploitation in a sustainable manner;
(b) To develop laws and regulations relating to groundwater exploitation management and groundwater quality protection;
(c) To establish a monitoring network for the survey and control of groundwater quality as well as quantity;

(d) To treat industrial waste before disposal;
(e) To have an environment impact assessment for all projects that may affect the quantity and quality of groundwater;
(f) To strengthen the capacity-building of government staff in the groundwater management sector;
(g) To improve public awareness on groundwater protection and conservation.

Finally, in order to enable the wise use of groundwater and to protect this resource from pollution and overuse, preventive development of water resources guided by sensible groundwater law and policies, implemented by a body clearly mandated to regulate and allocate the use of groundwater is needed.

2.3 EXPLOITATION OF LIVING AQUATIC RESOURCES

Living aquatic resources can be defined as resources living in water for all their life cycle, or spending their life frequently in water. The term living aquatic resources could be seen as an alternative to living wetlands resources. Another term known as wetland flora and fauna or the shorter one, wetland biodiversity, could also be considered.

This report will focus on the exploitation of two kinds of living aquatic resources, according to geographical location and characteristics of water, or alternatively speaking, the two main types of wetlands as follows:

(a) Living freshwater resources;
(b) Living marine resources.

2.3.1 Living freshwater resources

Some important flora and fauna on and in freshwater wetlands, called living freshwater resources, are as follows:

- Flora: flooded forest, aquatic plants, weeds etc.
- Fauna: fishes, shellfish, invertebrates, reptiles, small mammals and waterbirds.

The exploitation of living freshwater resources in Cambodia has been more intensive in recent years, leading to what is called unsustainable use, as a result of human pressure through various improper practices.

2.3.1.1 Status of exploitation of flooded forest, aquatic plants and weeds

Cambodian freshwater wetlands have been renowned as one of the world's most productive ecosystems because of the great abundance of flooded forest, aquatic plants and weeds that constitute the habitats for a wide variety of wildlife species, mainly fishes, shellfish, invertebrates, small mammals, reptiles, waterbirds and others.

(a) Productivity

The capacity of flooded forest, aquatic plants and weeds in producing yields (for example, per hectare, per year) of fishes, shellfish and other water or wetland related resources is not known because of a lack of systematic or scientific studies conducted specifically for such valuable ecosystems. The same constraint holds good when trying to estimate the amounts (in m^3 or in tons) of

timbers and charcoals and other materials yielded annually from the flooded forest throughout the country. For this reason, aquatic plants (for example, reeds, sedges and weeds) are not discussed in this report.

(b) Areas and extent of flooded forest

The Cambodian Land Cover Atlas prepared by the Mekong Secretariat in1994 for an FAO project (CMB/92/005) could be an important basis for the required data on flooded forest extents, as well as for those of important/selected wetlands and other land cover or land uses. The atlas covers three significant periods: 1973-1976, 1985-1987 and 1992-1993.

According to this atlas, the areas of Cambodian flooded forest are as follows:

Table 2.15 Flooded forest areas and trends

Period	**Area of first class** (km^2)	**Area of secondary class** (km^2)	**Percentage from total country area**
1973-1976	9,379	-	5.16
1985-1987	7,954	262	4.52
1992-1993	33,707	2,596	3.47
From total land area : 181,535 km^2			**100 per cent**

Source: Cambodia Land Cover Atlas,1994.

The areas mentioned above only refer to the flooded forest around Tonle Sap Great Lake, as stated in the introduction of the atlas.

Around Tonle Sap Great Lake, flooded forest presents a huge belt varying in size from 25 kilometres at the south-eastern edge of the lake to 60 kilometres at the western edge of the lake in Battanbang province. The location of flooded forest along with other ecosystems / land use of Cambodia can be seen in figures 2.15, 2.16 and 2.17.

Some activities that are considered a disturbance or threat to the flooded forest and that sometimes cause serious degradation and loss of vital ecosystems, are as follows:

- Cutting for firewood and charcoal (cooking energy generation);
- Cutting for construction / housing and fishing materials;
- Reclaiming agricultural lands / clearing for croplands;
- Burning to catch reptiles, snakes, turtles etc.

(c) Species diversity

There is a large diversity of trees species in the flooded forest, some of the important ones are as follows: *Barringtonia acutangula, Xanthrophyllum glaucum, Diospyros Cambodiana, Hymenocardia wallichii, Cococeras anisopodum, Unearia, Homomalla, Caparir micrantha, Streptegyne parvifolia, Bridelia Cambodiana, Cudrania Cambodiana, Grewia Sinuata wall,*

Phylantus taxodiifolius, *Homallium brevidans*, *Terminalia chebula*, *Amelia asiatica*, *Hydrocarpus anthelmintica*.

Apart from these important trees, there are many species of shrubs, aquatic plants, herbs and weeds. In general, the main aquatic plants can be grouped into:

- Rooted-emerged plants, inundated sometimes for 6-7 months or almost year round (for example, flooded forest trees);
- Rooted-floating leaves: *Trapa natans*, *Nymphaea sp.*;
- Non-rooted submerged plants: *Utricularia* species;
- Non-rooted floating plants: water hyacinth (*Eichhornia crappies*) is a dominant species. The others are: *Pistia stratiotes*, *Salvinia*.

There has been very little information on these aquatic plants, especially their productive capacity. No exact data can be found for these ecosystems, other than that they are important habitats for wildlife, particularly fish and other aquatic animals, and vital sources of food and materials for people.

(d) Management and conservation status

At the moment, we face many threats and constraints in the management and conservation of flooded forest and aquatic plants because of the increasing survival needs of the people and the fast growing development processes, mainly economic and socio-economic. The fund shortages and lack of policy and legislation for specific ecosystems constitute additional crucial constraints in the sustainable use and management of aquatic resources. Important national measures or initiatives taken for the protection, management and conservation of flooded forest and valuable wetland resources are:

- Designation of some important wetlands, such as Tonle Sap, Dong Peng and Samlot, as multiple-use areas among the 23 protected areas of Cambodia (by Royal Decree of 1 November 1993). Please refer to figure 2.18 for Cambodia's protected areas system;
- Law on Environment Protection (November 1997);
- National Wetland Action Plan;
- Accession to the Convention on Wetlands of International Importance (Ramsar Convention), Biodiversity Convention.

2.3.1.2 Status of fishery: exploitation, management and conservation

Cambodia is endowed with very abundant freshwater resources from rainfall averaging 1200-1800mm/year and flood water from the Upper Mekong River basin of many billions of cubic metres a year. The major water bodies of Cambodia are:

- Mekong River and its tributaries and associated floodplain lakes;
- Tonle Sap Great lake, the first main tributary of the Mekong River, and tributaries and related lake systems;
- Bassac River, the second main tributary of the Mekong River.

These ecosystems are among the most productive in the region, as well as in the world, because of the great range of biodiversity, mainly fishes. The fishery production from these waters contributes to the health of people as well as to the national economy.

(a) Productivity

Cambodian waters (both inland and coastal) have a highly rich biodiversity, including fish, shellfish, reptiles and many other aquatic resources. There are, according to some international estimates, 850 species of fish in the major freshwater bodies of Cambodia, mainly in the Mekong River and Tonle Sap Lake and associated flooded plains (Directory of Asian Wetlands, Scott 1989). However, the most recent studies on freshwater capture fishery in Cambodia (Danida funded project, completed in 1997) found some 215 species of fish in Cambodian freshwater bodies. This figure was also suggested by Kottelat in 1986. Many species are still unknown and need to be identified.

(b) Exploitation status

- **Catch levels in the past**

There are different figures on fish catches from Cambodian freshwater bodies:

1. 120,000 mt (metric tons), from which 50,000mt was from Tonle Sap Lake (Chevey and Le Poulin 1940);
2. Total catch level of 120,000t-130,000t, in the period 1962-1963, of which 50,000t were from Tonle Sap Great Lake 55 per cent representing family and small-scale fisheries (Fily and d'Aubenton 1965);
3. Total catch of 147,000t in1939 and 130,000t in 1957 (Badach 1969);
4. 125,000 - 160,000 t/year for total freshwater fishery, of which 50,000 –80,000t from the Tonle Sap River alone (University of Michingan 1975).

- **Recent catches**

The figures of the Fishery Department (Ministry of Agriculture, Forestry and Fishery) could be useful references, although reportedly under-evaluated. Table 2.16 shows the levels of fish catches through the period 1980-1995, and the comparison of fish catches in Tonle Sap and the total catches of inland fishes in Cambodia:

Table 2.16 Total inland fish catch in Cambodia, 1982-1995

Year	**Total inland catch** (tons)	**Tonle Sap catch** (tons)	**Tonle Sap catch as a percentage of total catch**
1982	65,700	40,070	61.0
1983	58,717	40,065	68.2
1984	55,093	53,392	64.2
1985	56,400	30,250	53.6
1986	64,181	31,063	48.4
1987	62,154	37,355	60.1
1988	61,200	32,585	53.2
1989	50,500	31,905	63.2
1990	65,100	36,790	56.5
1991	74,700	41,200	55.2
1992	68,900	40,568	58.9
1993	67,900	39,500	58.9
1994	65,000	38,550	59.3
1995	72,500	39,269	54.2

Source: Ministry of Agriculture, Forestry and Fisheries, 1996.

Based on these figures, it is clear that Tonle Sap Great Lake can provide more than half of the inland fishery production of Cambodia (table 2.17), and it remains one of the major sources of animal protein for the Cambodian people. The important species, including some commercial fishes, that are considered as grade one, are shown in table 2.18.

Table 2.17 Projected demand for fish, 1995-2005

Year	**Estimated population** (millions)	**Demand at current consumption rate** (10.6kg/capita/year)	**Demand at minimum nutritional requirement** (21.5kg/capita/year)
1995	10.0	106,000	215,000
2000	11.4	120,000	245,000
2005	12.9	137,000	277,000

Source: Ministry of Environment.

Table 2.18 Grade of fish species in the inland capture fisheries in Cambodia

Common name	**Scientific name**
Spotted leatherback	*Notopterus chitala*
Grey leatherback	*Notopterus notopterus*
Black tipped silver shark	*Balantiocheilus melanopterus*
Greater black shark	*Morulius chrysophekadion*
Solider river barb	*Cyclocheilichthys enoplos*
Smith barb	*Puntioplites proctozysron*
Red tail trifoil barb	*Puntius altus*
Schwanenfelds trifoil barb	*Puntius schwanenfeldi*
Great bony lipped barb	*Osteocheilus melanoptera*
Common silver barb	*Puntius pierrei*
Small scale mud carp	*Cirrhina microlepis*
Hoeven's slender carp	*Leptobarbus hoeveni*
Striped catfish	*Pangasius sutchi*
Yellow mystus	*Mystus nemurus*
Twisted jaw sheatfish	*Belodontichthy dinema*
Common sheatfish	*Kryptopterus apogon*
Siamese river abramine	*Cultrops siamensis*
Black-ear catfish	*Pangasius larnaudi*
Giant snakehead	*Channa micropeltes*

Source: Csavas and others, 1994.

The number of boats and catch per boat during the period 1982-1995 is presented in table 2.19.

Table 2.19 Number of boats and catch per boat, 1982-1995

Year	Total inland catch (tons)	Number of boats (tons)	Catch / Boat (tons)
1982	65,700	24,742	2.7
1983	58,717	26,611	2.2
1984	55,093	28,794	1.9
1985	56,400	32,593	1.7
1986	64,181	31,090	2.1
1987	62,154	31,841	2.0
1988	61,200	35,712	1.7
1989	50,500	35,942	1.4
1990	65,100	36,173	1.8
1991	74,700	34,859	2.1
1992	68,900	46,219	1.5
1993	67,900	18,489	3.7
1994	65,000	26,555	2.4
1995	72,500	27,101	2.7

Source: Department of Fisheries, 1993.

(c) Threats to living aquatic resources

There are increasing threats to living aquatic resources, both freshwater and marine. The main threats are human activities that create disturbance, reclamation, pollution, over-exploitation and degradation.

- **Disturbance**

This includes general disturbance from human settlement, encroachment for property, the dredging of rivers and lakes for construction, land fill impoundment for flood control, channeling and straightening of rivers in addition to disturbances caused by tourism and recreation activities.

- **Reclamation**

This includes reclamation for urban and industrial development, conversion to agriculture or croplands, and construction of infrastructure (roads, bridges, waterways).

- **Pollution**

The major sources of pollution to waters are mainly domestic wastes and municipal and town sewage. Please refer to section 2.2 for more detail.

- **Over-exploitation**

Over-exploitation of the fishery resources is becoming very intensive and leading to declines in fish stock.

- **Degradation**

This consists of human activities that reduce and alter the living aquatic resources.

2.3.1.3 Endangered / transboundary / migratory / species

Destructive practices, together with some illegal activities and inappropriate development as described above, have incontestably caused dramatic damage to most biodiversity components, mainly fishes, reptiles, waterbirds and aquatic vegetation, in recent years. Many of them have become increasingly threatened and endangered, some are now rare and even extinct.

According to some international studies, the endangered and rare species have been primarily identified as follows:

- **Mammals**

- Small-claved otter	(*Aonyx cinerea*)
- Smooth-coated otter	(*Lutra perspicillata*)
- Irrawaddy dolphin	(*Orcaella brevirostris*)

- **Birds**

- Sarus crane	(*Grus antigone*)
- Spot-billed pelican	(*Pelecanus philipensis*)
- Oriental darter	(*Anhinga melanogaster*)
- Asian-openbill (stork)	(*Anastomus oscitans*)
- Black-necked stork	(*Ephippiorhychus asiaticus*)
- Greater adjutant	(*Leptaplilos dubius*)
- Lesser adjutant	(*Leptoplilos javanica*)
- White winged wood-duck	(*Cairina scutalata*)
- Painted stork	(*Mycteria leucocephala*)
- Milky stork	(*Mycteria cinerea*)
- Giant Ibis	(*Pseudibis davisoni*)
- Wooly-necked stork	(*Ciconia episcopus*)
- Pallas's fish eagle	(*Haliacetus leucorypha*)
- Bar-bellied pita	(*Pitta ellioti*)
- Black-headed-Ibis	(*Threskionis melanocephala*)
- Comb duck	(*Sarkidionis melanotus*)
- Glossy Ibis	(*Plegodis falcinellus*)

- **Reptiles**

- Siamese crocodile	(*Crocodylus siamensis*)
- Indian python	(*Python indicus*)
- Giant Asian-pond turtle	(*Heosemys / gcoemida grandis*)
- Yellow-headed temple turtle	(*Hieremys annandalei*)
- Asian giant-soft-shell turtle	(*Pelochelys biberoni*)

- **Fish**

- Giant catfish (of Mekong)	(*Pangasianodon gigas*)
- Seven-line barb	(*Probabus jullieni*)
- Giant barb	(*Catlocapio siamensis*)

Among these threatened, endangered and rare species are some that are transboundary or migratory, such as Sarus cranes, pelicans, ibises. These have been observed to be migratory birds (coming and going from neighbouring countries, Viet Nam, the Lao People's Democractic Republic and Thailand and probably also from other countries in the Asia region). Irrawaddy dolphins are important fishes (or mammals) migrating between Cambodia and the Lao People's Democratic Republic.

There have been no exact and comprehensive identifications of migratory species of wildlife because of a lack of systematic scientific research.

2.3.1.4 Major problems and issues

The major problems and issues can be identified as the following:

- Decline in biodiversity: Fish, waterbirds, mammals, reptiles, invertebrates etc.
- Degradation and loss of natural habitats/ breeding, feeding and nursery grounds for fish and waterbirds in the potentially important ecosystems of the Mekong River and related floodplains and the Tonle Sap Great Lake, along with associated tributaries and lakes.
- Declining water quality, caused by the long-lasting and increasing pollution or contamination from urban and domestic wastes, direct discharge of sewage etc.

Consequently, natural disasters are often encountered:

- Increased sedimentation and siltation;
- Erosion, destruction of soil structure, landslides, mudslides;
- More frequent floods and droughts;
- Lack of food from aquatic sources.

2.3.1.5 Economic losses because of over-exploitation

It is evident that the over-exploitation of living aquatic resources can cause economic losses, in addition to serious impacts on the environment and many socio-economic problems, such as ecosystem deterioration, decline in biodiversity, habitat loss, difficult income generation, and damage to people's health and food shortages. The decrease of national revenue/GDP can be another example of the consequences of over-exploitation.

As no study or economic valuation of wetland ecosystems has been carried out so far, there are no certain figures on the economic losses caused by over-exploitation. However, in reality economic losses must be enormous.

2.3.1.6 Fish supply and demand

Fishery resources can be a vital source for economic development. Freshwater fishes constitute the major food of the people, providing about 40 - 60 per cent of the protein intake (Csavas and others 1994). The supply and demand of fish are as follows:

- **Supply**: Please refer to table 2.16 for fish production in Cambodia.
- **Demand**: Average per capita consumption during the period 1987-1994 was 10.6kg/year (Ministry of Environment).

This consumption rate is much lower than that prior to the internal conflict period of 1974-79 which was in the range of 20-25 kg per year (Lagter 1976). The apparent consumption of fish and fishery products in Cambodia in 1991-93 was estimated to be about 10.3 kg/year (FAO 1997).

The minimum nutritional requirements could be satisfied with a higher consumption rate of 21.5 kg/year. The projected demand for food fish would then be in the range of 120,000 to 245,000 metric tons by the year 2000 and 137,000 to 277,000 metric tons by 2005. In conclusion, inland fisheries instead of marine fisheries play a very important role in the food security of the country and

currently supply about 70 per cent of the total fish production, which averaged 113,450mt. annually in the period 1990-92.

As the over-exploitation of fishery resources has increased continuously over the last decade, the scarcity of such a valuable asset is becoming one of the most important national concerns. Thus, the projected figures mentioned above might not be met.

2.3.1.7 Causes including sectoral demand and failures and internal and external market demands

- **Causes for increased demand for fish**

Some factors that have been suggested are:

- Fast growth of population leading to increasing needs;
- Poverty and inadequate knowledge and understanding about the wise use of natural resources and the environment;
- Political will versus the current global concept of sustainable development (no strict control on activities that damage wetlands and aquatic resources);
- Abuse/ambition of foreigners (fishermen and investors);
- Improper management of fishery resources (illegal and destructive fishing practices);
- Failures of fishery management;
- Impossibility of controlling illegal and destructive fishing practices;
- Inappropriate fishing concessions, no limitation on the expansion of fishing lots, very intensive catches;
- Lack of a better understanding of the impacts from improper aquaculture;
- Failure in maintaining fishery resource richness and diversity of species, no wise use or unsustainable management leading to dramatic declines in fish stock and increasing numbers of threatened and endangered species of fishes, mammals and reptiles;
- Habitat degradation for fishing purposes;
- Failure to increase the national budget from fishery, much under-evaluated yield;
- No exact figures on fish capture during the last decade.

- **Internal and external market demands**

Freshwater fishery production for internal market demands is larger than that for external market demands. It has been estimated that about 90 per cent of freshwater fish caught in Cambodia is for internal consumption. Some commercial fish in a small quantity (about 10 per cent) have been exported to neighbouring countries, mainly Thailand and Viet Nam. These are freshwater lobsters, elephant fish, striped catfish and others. Most of them are transported in the form of frozen or iced fish. No study or record provides the precise level of internal and external market demands at the current time.

2.3.1.8 Impacts of global climate change

The main global change facing Cambodia and all countries in the region, as well as in the world, is the greenhouse effect, causing global warning. The consequences could be:

- Irregular rainfall;
- Prolonged drought negatively affecting agricultural production;
- Other El Nino effects.

2.3.1.9 Proposed interventions

The urgent needs are:

- The development and enforcement of laws and policies;
- Capacity-building and expertise improvement;
- Efforts in systematic / scientific research on living aquatic resources;
- The development of comprehensive conservation programmes/ strategies, management plans and master plans;
- National, regional and international database establishment and appropriate management;
- Living aquatic resources regional networking and collaborative efforts towards a regional action plan.

2.3.2 Living marine resources

Living marine resources include: mangroves, coral reefs, seagrasses, all vital habitats and nursery grounds for fish and shellfish. However, we would like to leave coral reefs, mangroves and seagrasses for further discussion in marine habitats in sections 2.4.2.2, 2.4.2.3 and 2.4.2.4.

2.3.2.1 Status of marine fishery productivity and fish catches

There has been little information on marine fishery in Cambodia. However, some figures of marine fish production during the period 1980-1995 are presented in table 2.20 and the number of coastal fishing boats in the period 1983-1993 is shown in table 2.21.

Table 2.20 Total annual marine fishery harvests, 1980-1995

Year	**Total catch** (in tons)		**Year**	**Total catch** (in tons)
1980	1,200		1988	21,000
1981	814		1989	26,050
1982	3,015		1990	39,900
1983	9,444		1991	36,400
1984	7,721		1992	33,700
1985	11,178		1993	31,100
1986	7,247		1994	30,000
1987	17,417		1995	30,500

Source: Department of Fisheries, 1996.

In 1994, there were 6,173 vessels in the marine sector with engines less than 10hp. (Fishery Department Registration). As there are no systematic studies or scientific research on marine fish and other marine aquatic organisms, information and data on their productivity and ecology is very poor. There is no exact indication of the total number of marine fishes. However, Cambodian coastal waters are among the richest areas in biodiversity, including significant aquatic resources and marine endangered species, such as the dugong, green turtle, dolphins and sharks.

Table 2.21 Number of coastal fishing boats, 1983-1993

YEAR	Boats <5 t	Boats >5 t	Motorboat 11-30 HP	Vessels >30 HP
1983	553	n.a	446	408
1984	1801	n.a	539	416
1985	2,449	n.a	550	422
1986	2,453	n.a	553	461
1987	2,801	n.a	482	617
1988	2,807	n.a	531	722
1989	1,869	n.a	341	615
1990	1,179	263	489	844
1991	1,000	809	718	408
1992	945	502	1,162	367
1993	882	350	1377	436

Source: Tana 1994.

Fishing pressures

In recent years there have been intensive fish harvests and various fishing methods and techniques, including the larger scale fishery industry, that have practically replaced the traditional sustainable uses of the past. Fishing practices that are considered the main threats to marine fishes and are believed to be inappropriate and unsustainable are:

- Illegal fishing (in closed seasons, by prohibited fishing materials/gear, such as very small mesh-nets);
- Destructive fishing techniques (for example, dynamite fishing, electric shocks, electrofishing, push netting, large-scale trawling by large vessels of foreign fishermen);
- Increased aquaculture /shrimp farming;
- Indiscriminate catch of fishes /collection of shellfish, molluscs;
- Destruction of breeding and feeding grounds / habitats (for example, coral reefs, seagrass beds, tidal vegetation /mangroves);
- Over-fishing and increased by-catch for fish culture purposes.

2.3.2.2 Endangered, transboundary and migratory species

There is little data available for marine endangered species and transboundary or migratory species in Cambodia. Therefore, it is thought that green turtle, dugong, dolphins, sharks and others are endangered. Many other species could be considered migratory in the Gulf of Thailand and probably in the South China Sea. Efforts to establish scientific taxonomic research in the region for a comprehensive database must be encouraged.

2.3.2.3 Major problems and issues

The major problems and issues for marine fishery management are expected to be the impacts of over-exploitation on living aquatic resources:

(a) Environment issues

- Dramatic decline in marine fish stock because of illegal, destructive fishing practices and unsustainable uses such as dynamite fishing, electric shocks, push-netting, big-scale trawling and purse-seining, the use of very small-mesh nets, electrofishing, encroachment of large-scale fishing by foreign fishmen in the offshore areas, and the indiscriminate catches and collection of fish and shellfish. The increased by-catches are leading to long-term depletion of the marine fish population;

- Subsequent decline of other marine biodiversity components depending on fish for their subsistence such as waterbirds, shorebirds, and marine mammals;

- Coastal waters are becoming more turbid because of intensive fishing activities, and as a result, the beaches have become degraded (for example, Kep Beach in Kampot province);

- Habitat degradation and losses, damaging the feeding, breeding and nursery grounds of fish, invertebrates and waterbirds;

- No ecological balance;

- Food-chain accidents.

(b) Socio-economic problems

- Reduced goods and services or limited employment for local people;

- Falling incomes or family economy problems, causing subsequently lower living standards, followed by poverty, shortages of food and other nutritional needs;

- Conflicts between users (fishermen, woodcutters and local people) and conservationists, or between the private sector, including businessmen and investors, and the public sector or government agencies;

- Loss of national budget from marine and coastal living resources sectors;

- Decreased income from tourism and recreation activities;

- Lack of significant historic sites and important species for research and education.

2.3.2.4 Economic losses because of over-exploitation

There are economic losses at some levels because of the over-exploitation of living marine aquatic resources. This can be seen in the lower living standards and the decreased national revenue from such sources. But the exact amount is not known because of a lack of systematic economic valuation. The lack of political will, the lack of funds and the security problem are seen to be the reasons for an absence of studies.

2.3.2.5 Causes and demands of over-exploitation

(a) Causes

The root cause for the over-exploitation of living marine resources is the fast growth of population in the coastal zone. This has resulted from the on-site growth of native people (or residents) and the increasing migrants, temporarily inhabiting the coastal areas while looking for new jobs, additional and supplementary to the old ones in their homelands. Some foreign migrants, mainly Thai and Vietnamese, could also be aggravating the situation of the marine and coastal environment.

Increasing poverty and falling income from crop harvesting and fishing are other competing causes for the over-exploitation of living marine resources, particularly marine fish, coral reefs, mangroves and seagrass destruction.

Coral and charcoal made from mangroves have often been exported by Thai people from Cambodian territory (adapted from provincial environmental offices). The same practices occur for fish, shrimp and timber from Cambodian coastal areas.

Therefore, it is possible to conclude that apart from the root causes (fast growth of population, poverty and income generation), there are immediate causes such as the need to seek alternative livelihoods, to improve living standards, to satisfy increasing needs for food, and to export by foreigners (transboundary needs).

(b) Demands

It is incontestable that the primary demands are for food security (demands for fish food) or subsistence/survival needs. Many other needs could be mentioned as secondary demands such as home or habitat security, health demands, clothing demands and development needs.

The important food for Cambodian people as well as for people in other Asian countries is rice. Some other crops (maize, bean, potatoes) are temporarily alternatives. The increasing demands for foodhave led to conflicting efforts in some areas: agricultural lands/croplands, fishing lot concessions/expansions, transport and navigation, mining, tourism, and recreation development, protected areas and habitats development. All of these seem to be increasing demands for economic and environment/conservation developments.

Demands for food (marine food) can not be completely described. It seems there has been no specific valuation of the demands for marine fish food. But there have been some estimates as to fish consumption and the projected demands for fish in general for the period 2000 and 2005. Please refer to the previous section 2.3.1.6 for the figures.

(c) Failures in living marine resource management

These consist of the following:

- Lack of strict control on fishing activities and illegal practices by foreign fishermen, and the occurrence of some destructive practices (push-netting, dynamite fishing, electrofishing, very large-scale fishery industry, use of very small mesh-nets, indiscriminate catches and collection of fish and shellfish/molluscs);
- No effective protection measures or strategy for reducing and banning all these illegal and destructive fishing practices and for conserving marine endangered living resources, including significant commercial fish;

- Absence a comprehensive conservation programme, action plan/ management plan for living marine resources;
- Improper development of coastal aquaculture / intensive shrimp farming, allowing the contamination of adjacent coastal waters;
- Increased export of charcoal made from mangroves and the intensive destruction of vital coastal habitats for marine lives;
- Excessive expansion of salt fields, causing drastic losses of mangroves and rear mangroves;
- Growing initiatives for some other inappropriate investments and developments in the coastal zone that could lead to destruction instead of conservation.

(d) Internal and external market demands

Information on internal and external market demands remains poor because of the absence of systematic studies. This needs to be developed and updated in the future.

2.3.2.6 Impacts of global climate change

The main impacts of global change are the effects of global warming, resulting in:

(a) Drought, very high temperatures of around 40 ^{0} C (maximum temperature in the dry season) that make for very fast evaporation of surface water and difficult growing conditions for plants and animals;
(b) Bad conditions for people's health;
(c) Irregular rainfall / short rainy season;
(d) Sea level rise.

2.3.2.7 Proposed interventions

(a) Collaborative research on living marine resources in the Gulf of Thailand;
(b) Systematic studies/ research on the endangered, rare and migratory species of living marine resources;
(c) Networking, establishment and management of databases on living marine resources;
(d) Strict control and banning of illegal and destructive activities in the coastal zone;
(e) Improved public awareness on the importance of living marine resources;
(f) Zoning and mapping for living marine resources;
(g) Creation of living marine resources reserves and protected areas;
(h) Formulation of law and policies, guidelines and regulations for the sustainable management and development of living marine resources.

2.4 MODIFICATION OF AQUATIC HABITATS

It is necessary to consider two distinctive aquatic habitats:

- Freshwater;
- Marine and coastal.

2.4.1 Freshwater aquatic habitats

The main components of freshwater habitats are:

- Freshwater vegetated wetlands, constituted by flora communities: Flooded forests and other aquatic plants and weeds (Palustrine system);
- Water bodies, open surface waters: lakes and rivers (lacustrine and riverine systems).

2.4.1.1 Freshwater vegetated wetlands

Cambodia has large tracts of freshwater wetlands that are vital habitats for a wide variety of species. Wetland habitats are very productive ecosystems as they contain many significant species of flora and fauna and provide several goods and services to the people.

According to some international estimates, Cambodia possesses at least 3.65 million hectares of wetlands of international significance. These are distributed in four potential areas in Cambodia as follows:

- Mekong River, together with its associated lakes, tributaries and floodplains;
- Tonle Sap Great Lake and its related tributaries and associated lakes and flooded areas;
- High floodplain of Stung Sen (the longest tributary of Tonle Sap Lake);
- A system of rivers with mangroves swamps in Koh Kong province (see the location of internationally important wetlands in Cambodia in figure 2.19 extracted from the Directory of Asian Wetlands, Scott 1989).

There is no specific area for each of these four potentially important sites, but it could be estimated at almost 2 million hectares for the potential system of the Mekong River and more than 1.65 million hectares for the remaining three sites. However, as Cambodia is endowed with extremely rich freshwater systems comprising the Mekong River, the Tonle Sap Great Lake, Tonle Bassac and many tributaries and associated inundated plains and lakes systems, it could contain internationally important wetlands at a greater percentage (more than 20 per cent) of the total country (181,535 km^2), and at 5 per cent of Asian wetlands.

Indeed, most of Cambodia's land is seasonally flooded for some months during the wet season (from May to October). Therefore, it is believed that Cambodian freshwater wetlands cover a relatively large area in comparison to those at the coast.

Freshwater wetlands can be classified mainly as:

- Natural and artificial or man-made;
- Permanent and seasonal or temporary;
- The major systems are: riverine, lacustrine palustrine and marine estuarine.

This is made according to the commonly known Ramsar definition and based on the International Union for Conservation of Nature and Natural Resources (IUCN) classification.

However, there has been little information and data on the specific types of freshwater wetlands and marine and coastal wetlands. We would like, therefore, to discuss only the well-known types of freshwater wetlands and habitats and leave many others as accidental gaps, to be completed later.

However, some selected wetlands could be identified and considered as a preliminary step. These are: rice fields (rainfed and recession), flooded forest, flooded grasslands, swamps, and marshland open waters (lakes, rivers and sea). As the areas of each of these ecosystems can be identified clearly on the Cambodia Land Cover Maps prepared in 1994 by the Mekong River Commission Secretariat and other maps, their changes or modifications over the two last decades can be depicted. Please refer to figures 2.16 and 2.17 in section 2.3.1.1 and table 2.15 for the location and extent of each of these habitats.

A. Rice fields

(i) Change in area of rice field ecosystems

There have been some changes in the extent of rice fields (rainfed and receding rice) as presented in table 2.22 below:

Table 2.22 Changes in rice ecosystems, 1973-1993

Period	**Rainfed rice** (Km^2)	**Receding rice** (Km^2)	**Total** (Km^2)
1973-1976	25,290	-	25,290
1992-1993	26,097	293	26,390
Increase	**807**	**293**	**1,100**

Source: Cambodia Land Cover Atlas, 1994.

The main causes for changes in rice ecosystems are from some basic factors: warfare, population growth, poverty, security problems and development trends. Economic development, mainly in the agricultural sectors, has intensified during the last decade, controversially sometimes as to its effects on sustainable development (for example: rice field expansion, over-fishing, over-grazing). Natural forested lands have been cleared for agricultural lands, rice fields and other croplands. This can lead to the dramatic degradation and loss of vital habitats for wildlife, especially the loss of significant species of flora and fauna. Subsequently great economic loss can be expected. Unfortunately, the exact figures in this regard are not available because of a lack of studies and research.

According to table 2.22 (adapted from the Cambodia Land Cover Atlas, 1994) the areas for rice paddy are as follows:

- 26,097 km^2 for rainfed rice and 293 km^2 for recession rice in 1992-1993;
- 25,290 km^2 for rainfed rice in 1973-1976.

These figures reveal a negligible area of recession rice during the period 1973-1976 and a relatively small area of rainfed rice, if compared with that in 1992-1993. Accordingly there has been a total increase of 1,100 square kilometres, distributed as 807 square kilometres for rainfed rice and another 293 square kilometres for receding rice in that period.

Change is expected as a result of the destruction of flooded forest and vegetated wetland for conversion to another freshwater habitat, rice fields.

For species composition change, there exists very poor information and data. No estimates on the number of rice species in the past or at the present time exist. One can only assume that many traditional planted or native rice species have been replaced by some newly introduced species (for example, IR 42, IR 36).

(ii) Conflicting uses

There have been conflicting uses of rice fields because of various development practices:

- Agricultural developments: Traditional rice and other crops versus the newly initiated rice field-fish farming;
- Industrial development: many rice fields have been filled for the construction of factories, manufacturing and handicraft establishments, petroleum stations and others;

- Housing / settlement (urban expansion);
- Other buildings and infrastructure.

However, these competing development processes are actually detrimental for ecological resources, in particular for fish, shellfish, invertebrates, reptiles and other aquatic organisms. It is possible to conclude that Cambodia has been facing in recent years unsustainable agricultural production despite the absence of studies of the conversion of flooded forest to rice fields and agricultural lands to other systems as mentioned above.

(iii) Causes of habitat change

These include production increases and some other purposes such as the expansion of plantation areas, decrease of soil fertility, natural disasters and erosion from run-off.

(iv) Impacts of global change

Some of the impacts of global change are:
- Low yields because of irregular rainfall and pronounced drought or increased evaporation;
- Rice disease frequency.

(v) Economic losses owing to habitat modification

There could be serious losses, but no comprehensive estimates have been undertaken. Therefore, this has been left for further studies and research.

(vi) Major areas of impact

The major areas of impact are observed in the central plains of Cambodia, around Tonle Sap Great Lake and some other localities (please see figures 2.15 and 2.18 for important locations).

(vii) Proposed interventions

- Comprehensive studies and research on rice ecosystems;
- Ecologically sound management of rice field habitats;
- Efforts for sustainability in agricultural production (pesticide use control);
- Land use policy and law development and enforcement;
- Limitation on industrial developments and other improper development practices.

B. Modification of flooded forest habitats

Flooded forest is the second most important freshwater habitat after rice fields. It plays a crucial role as life support for a number of people and wildlife species in and around the areas of flooded forest.

Flooded forest in Cambodia can be found abundantly around the Tonle Sap Great Lake and in some other locations along the Mekong River and its associated floodplain lake systems (see the location of flooded forest in figures 2.15 and 2.18 in the previous subsection). The areas of flooded forest, along with the change in area are available from the Cambodia Land Cover Atlas 1994, prepared by the Mekong Secretariat.

The characteristics of flooded forest are:

- The creation of a broad belt, 25-60 kilometres wide, around Tonle Sap Lake;
- Filtering layers for sediments and silts discharged from upland catchment run-offs;
- Feeding, breeding and nursery grounds for fishes and water birds.

(i) Changes in the extent and quality of flooded forest

Cambodia possesses large tracts of freshwater swamp forest, principally in a broad belt around the Great Lake and at certain localities along the lower Mekong and its related tributaries and associated floodplain systems. There have been various interpretations of the extent and quality of flooded forest (or swamp forest) in Cambodia's freshwater areas.

However, the estimates in 1970 provided the figure for the total area of flooded forest as 680,000 hectares. Recent estimates have suggested that only 564,000 hectares remain (Directory of Asian Wetlands).

However, according to the Mekong Secretariat (from landsite imagery made during 1973-1993), some slight differences in this regard can be found. Please see table 2.15 in section 2.3.1.1 for the categorized areas, together with the percentage of flooded forest from the total land area of Cambodia.

The Cambodia Land Cover map (figures 2.15, 2.16 and 2.17) in 1973 classified 9,379 square kilometres of flooded forest in the pristine stage and as evergreen. Since then, the traditional practices of local communities have contributed to the misuse or unsustainable utilization of flooded forest, and subsequently, the wildlife as well. These uses are: cutting for firewood and charcoal production, cutting for fishing materials and traps, fishing areas (fishing lots) expansion, clearing for agricultural lands (rice fields and other croplands), burning to catch animals (snakes, turtles, frogs), and burning to get honey. As a result some 5,672 square kilometres of flooded forest of the best quality had been lost by 1993, and only 3,707 square kilometres remain, with 2,596 square kilometres left as relatively bad or in the secondary class. This has clearly revealed the continuing change in the quality of flooded forest and the loss of some 3,076 square kilometres of the total area over 20 years. The trends over the last two decades could be presented as follows:

Table 2.23 Trends in flooded forest extent and quality

Period	**Extent** (in km^2)		**Total area** (in km^2)	**Percentage of best quality of**
	Pristine	**Secondary**		**Flood forest**
1973-1976	9,379*	-	9,379	100*
1991-1993	3,707*	2,596	6,303	39.5*
Over 20 years			**(-) 3,076 or 32.7 per cent**	

Source: Cambodia Land Cover Atlas, 1994.

Note: (*) Estimated as the extent and percentages of flooded forest in the pristine stage (or of best quality) in the periods 1973-1976 and 1992-1993;
(-) Decrease in area of flooded forest and percentage from the total area of flooded forest in 1992-1993.

(ii) Change in species composition

This can be seen when conducting surveys or visiting some important wetland sites, such as the Tonle Sap Great Lake, the Mekong River and floodplain lakes. The people living on and around these areas have traditionally used flooded trees, mainly the tall/big species for energy generation (for cooking, baking and refining energy).

Among the important trees previously mentioned (in section 2.3.1.1), we have observed that some are preferred for the above purposes: *Barringtonia acutangula*, *Homallium brevidans*, *Hydrocarpus antelmentica* and some others. These species have been intensively used and might become scarcer and scarcer.

It seems hard at the moment to seek exact data on the rates for the destruction and the losses of these species in particular, and of the flooded forest of the whole country in general. This is because of the absence of comprehensive studies and research in such areas.

(iii) Conflicting uses

The uses of flooded forest around Tonle Sap Great Lake, as well as in other localities of Cambodia, along with other freshwater habitats throughout the country, are facing increasing conflicts among users. The natural resources and biodiversity, for which the flooded forest is a crucial component, have been used for diverse purposes by different sectors. They have been intensively exploited mainly by the agricultural sector, comprising local farmers and fishermen. The Fishery Department has had a regulating and managing role in the fishery and flooded forest management and development.

The Tonle Sap Great Lake is the most concentrated area and the biggest centre for aquatic flora and fauna, probably the most famous habitat in Cambodia and perhaps in the region because of very abundant and diverse species of flooded forest.

However, the traditional uses by local people, together with the recent management style, have likely aggravated the situation of flooded forest at Tonle Sap Great Lake. These vital habitats have been increasingly affected by ignorant communities and the ambitious practices of fishing lot concessionaires, backed by high ranking officers or the military.

(iv) Causes of habitat change

The main causes for changes in the extent and quality of flooded forest are:

- Population growth and food security needs;
- Income generation and alternative livelihood / living standard improvement;
- Economic developments, mainly enhancement of agricultural production.

These are considered the root causes for habitat/ flooded forest change. The other causes are discussed in much more detail in chapter 4.

(v) Impacts of global change

It is expected that some effects of global change, especially global warming, could influence the natural processes of vegetation growth because of higher air temperatures as well as water shortages, drought and irregular rainfall.

(vi) Economic losses owing to modifications of flooded forest

The economic losses from the modification of flooded forest could be of great concern and could reach a remarkable level. But, at present there exist no exact figures for the economic losses. Therefore, the economic valuation of such aquatic habitats is very necessary for our further efforts in this regard.

(vii) Proposed interventions

There have been some national measures and initiatives in terms of sustainable management and conservation of wetland resources and biodiversity, including flooded forest. The most important measures or initiatives taken are: the designation of three multiple-use areas among the 23 sites in the protected areas system of Cambodia (by Royal Decree of 1 November 1993). The location of these sites is given in figure 2.18.

In view of the continuing intensive threats to flooded forest around Tonle Sap Lake and other lakes, additional legal frameworks and tools for the most effective management and sustainable utilization of flooded forest are urgently needed.

The proposed intervention should be focused on:

- Law enforcement and policy development;
- Strict control on all developments and activities;
- Comprehensive systematic studies and research for the management of Tonle Sap as a multiple-use area in a sustainable and ecologically-sound way;
- Master plan development and strategy for the flooded forest of Tonle Sap Lake;
- Limitation of fishing lots and restriction of size.

2.4.1.2 Lakes, rivers and other water bodies

Lakes and rivers are very important water bodies, providing several goods and services for people and supporting life for a great variety of animals, particularly fish, shellfish, invertebrates, amphibians, cetaceans and many other aquatic organisms.

The major inland lake of Cambodia is the Tonle Sap Great Lake, the biggest lake in Cambodia and probably in the South-East Asian region as well. Cambodia possesses numerous other freshwater lakes throughout the country dependant or associated with the Great Lake and with the Mekong River, the "Mother" for all other water bodies as indicated in its name "Mekong: Water-Mother".

We would like to consider some important inland lakes, such as Tonle Sap Great Lake and its associated lake Boeng Chhmar, and two others: Boeng Veal Samnap and Boeng Prasat Tayo in Kandal province, and the delta lakes of the Mekong River. Many others have been left out of the discussion as there have been no studies and surveys conducted on them.

A. <u>Tonle Sap Great Lake habitat modification</u>

(i) Characteristics of the Tonle Sap Great Lake

- Maximum length: 125 km in the wet season
- Minimum length: 250 km in the dry season
- Maximum width: 70 km in the wet season

- Maximum surface: 13,000 km^2 in the wet season
- Minimum surface: 3,000 km^2 in the dry season
- Maximum depth: around 10m in the wet season
- Minimum depth: 0.8 m-1.0 m in the dry season
- Volumes: 73 billion.m^3
- Discharge (annual average): 317 m^3 / s
- Inflows and outflows following Mekong floods varying with the seasons (with the north-east and south-west monsoons).

(ii) Change of area of lake inundation and species composition

This refers to natural change following the hydrological regime, influenced basically by the floods on the Mekong River.

In the wet season, the great lake swallows flooding waters from the Mekong through the Tonle Sap River. It reaches its maximum inundated area of about 15,000 square kilometres at peak flooding time. In the dry season the lake area reduces to some 2,500 square kilometres. During that time the lake water flows out, changing direction southwards across the Tonle Sap River to the Mekong River.

(iii) Species diversity in Tonle Sap Lake

- Fauna : no exact figures, but it is believed there are a remarkable number of species;
- Flora expected in a remarkable amount;
- Fishes, evaluated at 850 species by most international experts, but only some 215 species have been so far identified, more than half remain unnamed;
- Other living aquatic resources : invertebrates, mammals, crustacean, and amphibian;
- Micro organisms: plankton (phytoplanktons zooplanktons);
- Other organisms remain unknown.

(iv) Conflicting use of areas

The conflicting uses of Tonle Sap Great Lake and other lakes in the different sectors are as follows:

- Agriculture: rice and some other crops;
- Fishery production by fishing lot concessions, subsistence (family fishing);
- Transport;
- Natural conservation/protected areas.

(v) Impacts of global change

The life cycle of lake biodiversity could be affected by global warming (for example, this can disturb the natural growing processes of plants and fishes) and the irregular weather (higher temperature, poorer rainfall). Drought could be caused, making the lake water warmer, and so creating difficult conditions for all life in the lake.

(vi) Economic losses owing to habitat modification

A systematic economic valuation of flooded forest, aquatic plants, fishes and water birds, and other products and services, provided by the lakes in the past and at present is needed. As this has not yet been done, precise figures on economic losses because of habitat modification are not available. However, the lakes are extremely valuable assets for humans and biodiversity.

The major areas of impact are the Tonle Sap Great Lake and many others in Cambodia. These lakes have been seriously impacted over recent years by agricultural production practices, the fast growing population and development.

(viii) Proposed interventions

Lakes, particularly the Tonle Sap Great Lake, have been and might be very important subjects for exploitation as well as for management and conservation.

The interventions should concentrate on:

- Strict controls and monitoring on all developments and activities on the lakes;
- Limitation of fishing lots and reduction of size;
- Law enforcement;
- Ecologically-sound management, conservation and development;
- Capacity-building for responsible staff;
- Financial support for the Tonle Sap multiple-use area management plan.

B. River habitat modification

Cambodia has a very abundant system of rivers and waterways that are important in many ways, socially, economically and ecologically. The most important rivers are the Mekong River and its two main tributaries, the Tonle Sap and Bassac Rivers, and many other tributaries.

Tonle Sap River itself has a huge catchment area which plays a very important role in Cambodian social, economic and environmental development.

The Mekong River in Cambodia flows for a distance of 486 kilometres from the northern border with the Lao People's Democratic Republic, southwards to the South China Sea, and finally crossing the Vietnamese delta. It is extremely significant in terms of human and wildlife support. It is classified among the world's longest rivers (ranked twelfth in terms of length and twenty-first in terms of annual mean discharge).

(i) Change in areas of rivers

It is hard to know the surfaces of all rivers throughout Cambodia. What is possible, is that we can check their lengths and catchment areas:

- Length of Mekong River in Cambodia: 486 kilometres;
- Catchment area for the Mekong River in Cambodia: 155,000 square kilometres (18 per cent from total Mekong River basin and 86 per cent from Cambodia's land);
- Average discharge: 15,000 m^3/s.

Changes in the area of the Mekong River and other rivers throughout the country are not known because of an absence of studies and research.

(ii) Habitat losses on the rivers

There has been long-lasting, traditional destruction of forest resources along rivers and on their floodplains and watersheds causing much damage to biodiversity and reducing benefits to the people.

(iii) Conflicting uses of rivers

Conflicting uses are as follows:

- Water supply for agriculture, domestic needs, industrial and other processes;
- Fishing;
- Transport, navigation;
- Conservation, water management;
- Settlement / floating houses;
- Tourism;
- Nature conservation (Ramsar site).

(iv) Causes of habitat change

The main causes are:

- Firewood and charcoal collection;
- Illegal logging / deforestation;
- Inappropriate fishing practices;
- Improper forest investments and concessions;
- Low capacity and expertise among government staff;
- No control and monitoring.

(v) Impacts of global change

It is expected that global warming will cause some changes in climatic patterns, such as temperature and rainfall, that will impose difficult conditions for the health and growing processes of people, animals and plants. As the river waters become warmer, life will become more difficult for the fish.

(vi) Economic losses owing to habitat modification

Quantifying the habitats of all rivers is difficult and estimating economic losses from habitat modification is no simple thing. This work requires expertise and financial resources for inventory, assessment and research.

(vii) Major impacted areas

- Mekong River and its tributaries and on associated floodplain systems;
- Tonle Sap River and its tributaries;
- Tonle Bassac and its tributaries;
- Coastal watersheds.

(viii) Proposed interventions

The following interventions have been proposed:

- Comprehensive studies and research on river ecosystems;
- Economic valuation of rivers and habitats modification;
- Strict control and ban on deforestation in river catchment areas;
- A ban on destructive fishing practices that damage river habitats;
- Capacity-building for effective and successful management, controls and research;
- Application of EIA for mainstream developments, particularly hydropower;
- Rational and sustainable use of the water resources of rivers;
- Campaign for public awareness enhancement on wise-use and sustainable management of habitats.

2.4.2 Marine and coastal habitats

For this, we would like to include:

- Estuaries and embayments;
- Coral reefs;
- Mangroves;
- Seagrass beds.

2.4.2.1 Estuaries and embayments

There is little information on estuaries and embayments because of a lack of studies and research. However, problems with coastal habitats have to be addressed and considered.

Because of the absence of available information, the change in areas and species composition of estuaries and embayment is very little known. It is expected that changes have occurred.

(i) Conflicting uses of areas

- Settlement and urbanization;
- Fishing (intensive and destructive) practices;
- Collection of firewood and charcoal production;
- Transportation and navigation;
- Industrialization;
- Nature conservation;
- Others developments: tourism and recreation.

(ii) Causes of habitat change

- Poverty of local people, growing numbers of fishermen;
- Generation of income for living standard improvement, growing survival needs;
- Improper management and development, and misuse of habitats;
- No strict controls and monitoring;
- Low capacity and lack of experience and skills among staff;
- Lack of policy and law, no law enforcement;
- Inappropriate land use / land encroachment.

(iii) Impacts of global change

Global warming could have some effects such as:

- Sea level rise (remaining uncertain at the moment);
- Temperature of waters becoming higher;
- Difficult conditions for residents in and around the area / health problems and diseases.

(iv) Economic losses owing to habitat modification

Owing to a lack of systematic valuation, the exact figures on economic losses caused by habitat modification remain unavailable. The economic losses could be remarkable. These might be one of the important concerns to be further considered and dealt with.

(v) Major impacted areas

The following areas should be considered:

- Prek Kompong Bay estuary, in Kampot province;
- Prek Kompong Smach, in Kampot;
- Kep Bay- in Kampot;
- Prek Toek Sap estuary, in Sihanouk Ville;
- Kompong Saom bay, in Koh Kong province;
- Koh Kong bay, in Koh Kong province;
- Prek Koh Poa and Stung Kep estuaries in Koh Kong.

(vi) Proposed interventions

- Strict controls on illegal and destructive fishing practices and development;
- Enhancement of understanding and awareness of local people on wise-use concepts and sustainable management of marine habitats;
- Capacity-building for staff on inventory, assessment techniques, comprehensive research;
- Appropriate land-use promotion, mapping and zoning;
- Policy and law formulation and enforcement;
- Management plan and strategy setting for estuaries, embayments and other marine habitats.

2.4.2.2 Coral reefs

Coral reefs are vital marine and coastal habitats, but very little is known about such ecosystems because of a lack of research.

(i) Change in areas and species composition

The sites of coral reefs are not completely identified. But based on some short surveys by responsible staff, coral reefs have been observed to occur in many localities in Cambodian coastal waters, generally around the inshore islands and on some rocky beds.

The areas of coral reefs have not been identified yet, but the species composition has been preliminarily identified and is presented in table 2.24.

Table 2.24 Hard coral reef species identified in the exclusive economic zone of Cambodia

N°	*Species name*	N°	*Species name*
1	*Posillopora cydouxi*	13	*A. danai*
2	*P. verrucosa*	14	*A. digitifera*
3	*Seriatoposa lystrix*	15	*A. echinata*
4	*Montipora confusa*	16	*A. formosa*
5	*M. danae*	17	*A. grandis*
6	*M. digitata*	18	*A. horrida*
7	*M. stellata*	19	*A. nobilis*
8	*Anacropora forbesi*	20	*A. palifera*
9	*A. puertogalerae*	21	*Acropora specie*
10	*Acropora cerealis*	22	*Porites nigrescens*
11	*A. elseyi*	23	*Alveopora specie*
12	*A. humilis*	24	*Coeloseris mayeri*

Source: Coastal Zone Management, Ministry of Environment, 1997.

Soft coral and sea fans

Identification of these resources has been made through fishermen interviews and available samples during the study period. The species composition of the coral reefs is presented in table 2.25.

Table 2.25 Soft coral reef species identified in the exclusive economic zone of Cambodia

N°	*Species name*	N°	*Species name*
1	Soft coral (*Lobophyton sp.*)	8	Gorgonian fan (*Melithaeidae)*
2	Soft coral (*Sarcophyton sp.*)	9	Gorgonian fan (*Plumigorgiaschuboti)*
3	Soft coral (*Sinularia sp.)*	10	Soft coral (*Dendronepgthya sp.)*
4	Gorgonian fan (*Subergorgia molis)*	11	Soft coral (*Euplexaura sp.*)
5	Sea fan (*Solenocaulon sp.*)	12	Sea fan (*Paracis sp.)*
6	Red whip coral (*Ctenocella)*	13	Sea fan (*Plexauridae*)
7	Red whip coral *(Ellisella sp.*)	14	Yellow whip coral (*Ellisalla sp.)*

Source: Coastal Zone Management, Ministry of Environment, 1997.

(ii) Conflicting uses of areas

- Coral mining for exportation;
- Fishing (dynamite);
- Coastal development and urbanization;
- Transportation and navigation;
- Tourism / recreation;
- Nature conservation and research.

(ii) Causes of habitat change

- Population, poverty, income generation;
- Illegal and destructive practices in fishing (for example, dynamite fishing);
- Inappropriate development and investment;
- Lack of awareness of local people on the importance and benefits of coral reefs;
- No policy and law, lack of law enforcement.

Impacts of global change

- Slow natural growing process because of possibly difficult conditions imposed by increased water temperature and changed tidal patterns;
- Rising sea level (possible but uncertain level);
- Irregular climatic regime, modified rainfall.

(v) Economic losses owing to habitat modification

This is not available because no studies or research has been specifically carried out yet.

(vi) Major impacted areas

- Around islands, in the coastal waters;
- Reefs flats, rocky shores / inshore areas;
- Some localities (unknown in subtidal areas) generally in the coastal zone: Kampot, Sihanouk Ville and Koh Kong.

(vii) Proposed interventions

As in section 2.4.2.1 for estuaries and embayments.

2.4.2.3 Mangroves

Mangroves are crucial habitats in the intertidal areas along the Cambodian coastline. They can be found in the estuaries, along the muddy seashore and on the swamps and river systems and some coastal areas.

(i) Change in areas and species composition

The comparison of mangrove areas could be presented as below in table 2.26. According to table 2.26, we can see an increase of 10,200 hectares of mangroves over 20 years, distributed as 4,100 hectares in Kampot province and 6,100 hectares in Sihanouk Ville. However, there is a considerably decreased area of 19,700 hectares in Koh Kong province. This makes a total decrease in mangrove area of 9,400 hectares.

Table 2.26 Mangroves in Cambodia

Period	**Area in coastal provinces** (ha)			**Total area** (ha)
	Kampot	**Sihanouk Ville**	**Koh Kong**	
1973 -1976	3,800	7,400	83,400	94,500
1992 - 1993	7,900	13,500	63,700	85,100
Trend over 20 years	(+) 4,100	(+) 6,100		
	(+) 10,200		**(-) 19,700**	**(-) 9,500**

Source : Cambodia Land Cover Atlas, 1994, prepared by the Mekong Secretariat.
Note: (+) increase, (-) decrease

It seems there is no clear reason for the increase and decrease of mangrove area in Cambodia over the last 20 years.

(ii) Conflicting uses of areas

Mangroves have been intensively used by diverse sectors, for different purposes:

- Firewood and charcoal production;
- Fishing and construction materials;
- Intensive shrimp farming;
- Salt production;
- Conservation of habitats, education and research.

(iii) Causes of habitat change

The change in mangrove habitat is observed from:

- Growing survival needs (of local poor people);
- Misuse and unsustainable practices;
- Low understanding and awareness of local people on the importance and benefit of mangroves;
- Low capacity among responsible staff;
- Lack of funds for research, controls and monitoring;
- Inappropriate developments: aquaculture, salt production;
- Illegal trade / exportation.

(iv) Impacts of global change

The main impacts expected from global warming are higher temperatures in the coastal zone making the water warmer. Mangroves can be affected by smaller and irregular rainfall, as an additional effect, and by some changes in hydrographic patterns (tides, current, waves and water level). But these impacts are relatively small when compared with human impacts.

(v) Economic losses owing to habitat modification

The modification of mangrove habitat has resulted in remarkable economic losses. But, as no study has been carried out, the precise amount is not known.

(vi) Major impacted areas

The major areas of impact are: mangrove swamp systems in Koh Kong province, and the mangroves in estuaries and river systems in Sihanouk Ville and Kampot Province. Mangroves in Koh Kong are the most degraded.

(vii) Proposed interventions

The proposed interventions should concentrate on:

- Strict controls and banning of illegal and destructive activities and development such as:
  - Illegal export of charcoals;
  - Improper shrimp culture;
  - Excessive salt production;
  - Collection for firewood and charcoal production;
  - Fishing and housing material from mangroves.
- Capacity-building for responsible staff;
- Surveys and research for mangrove conservation;
- Public awareness enhancement;
- Formulation of policy, law, regulations and guidelines.

2.4.2.4 Seagrass beds

Seagrasses are one of the vital habitats in the shallow coastal waters. They are very important for many fish, invertebrates and other marine organisms. There has been a problem with seagrasses as they have become increasingly threatened in recent years.

(i) Change in areas and species composition

The change in area of seagrass beds, together with species composition, is not well known because of a lack of comprehensive systematic research.

However, seagrasses can be found in most shallow waters in the coastal zone, namely in Kampot province, Sihanouk Ville and Koh Kong province. Kampot province has been seen as the most concentrated area in terms of diverse seagrasses species, while Koh Kong is an important point for at least one endemic species.

Based on some small surveys conducted recently, there are many localities in Kampot and some in Sihanouk Ville and Koh Kong that are important seagrass habitats, but the change in areas of seagrass beds or the composition of seagrass species can be not ascertained as they have not been studied and researched comprehensively.

(ii) Seagrasses species

Important species of seagrasses identified from some short surveys are:

- *Enhalus acoroides* (dominant species);
- *Cymodocea seradata*;
- *Syringodium isoctifolium*;
- *Halodule pinifolia.*

It is expected that there are 11-12 species of seagrasses in Cambodian coastal waters. At present, few species can be identified.

(iii) Conflicting uses of areas

- Fishing (by destructive gear, push nets, trawl nets);
- Transport;
- Conservation of species, education, research, reserves for endangered mammals.

(iv) Causes of habitat change

- Misuse, unsustainable management, (for example, fishing by push-nets, trawling, very intensive fishing activities);
- Intensive transport (waterborne) and navigation, making strong waves.

(v) Impacts of global change

This will be the same as for coral reefs (please refer to section 2.4.2.2).

(vi) Economic losses owing to habitat modification

As little is known about seagrass habitat, and no estimates on economic losses can be made, it is impossible to go into detail.

(vi) *Major impacted areas*

- Kep bay in Kampot province;
- Estuary of Perk Kampong bay and adjacent areas (in Kampot province);
- Kampong Saom bay (Koh Kong);
- Koh Kong bay (Koh Kong).

(vii) Proposed interventions

- Comprehensive studies and research on seagrasses;
- Strict controls on destructive fishing practices;
- Capacity-building for seagrass management;
- Formulation of policy and law, regulations and guidelines for seagrass conservation;
- Public awareness enhancement on seagrass benefits;
- Promotion of community involvement.